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# ***JPRS Report***

# **Science & Technology**

***CHINA: Energy***

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# Science & Technology

## China: Energy

JPRS-CEN-91-006

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7 June 1991

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### Energy Minister Discusses Energy Shortfall

916B0055B Beijing RENMIN RIBAO HAIWAI BAN  
in Chinese 2 Apr 91 p 4

[Article by reporter Li Huailin [2621 2037 2651]: "Huang Yicheng Talks About Reversing Energy Resource Shortage: Establish a Special Energy Resource Construction Fund, Create the Conditions To Develop Nuclear Power As Quickly As Possible, Cooperate on Both Sides of the Taiwan Strait To Develop Its Petroleum, Discussions and Preparations for Three Gorges Project Still Going On"]

[Text] Minister Huang Yicheng [7806 3015 6134] of the Ministry of Energy Resources said in Beijing on 1 Apr 91 that China's energy resource industry must strive to reverse the energy resource shortage situation in the next 10 years to ensure sustained, stable, and coordinated development of the national economy.

Huang Yicheng stated at two press conferences held in the [Beijing Xinhua] News Center on the morning of 1 Apr 91 that the state has agreed to the establishment of special construction funds for coal and petroleum similar to the one for electric power to increase investments in the coal and petroleum industries and ensure stable capital sources.

He said that substantial energy resource shortages persist during the Seventh 5-Year Plan, that they have become one of the primary factors that restrict development of the entire national economy, and that the main reason for this is a failure of the rate of growth in energy resources to adapt to the rate of growth in the national economy.

He said that over the next 10 years, primary energy resources in China must grow by at least 3 percent a year and that total output of primary energy resources must reach 1.2 billion tons of standard coal in 1995 and 1.4 billion tons in 2000.

When discussing strategic deployments and measures for development of energy resources in China, Huang Yicheng pointed out that: "we must first make full use of our energy resource advantages and accelerate the development of coal. In the next 10 years, we must strive to increase China's raw coal output by about 40 million tons a year."

He said in regard to hydropower construction that we should focus on construction of large and medium-sized hydropower stations on the upper reaches of the Huang He, the trunk and tributaries of the Chang Jiang, the Hongshui He, Wu Jiang, and the Lancang Jiang, and try to add 10,000MW in large and medium-sized installed generating capacity annually during the Eighth 5-Year Plan.

He said that we should actively develop pit-mouth power plants, reinforce power grid construction, shift from transporting coal to transmitting power, and reduce pressures on transportation. We now have preliminary

plans to build about 30,000MW in pit-mouth power plants over the next 10 years, which could conserve about 100 million tons of coal haulage capacity. Several power plants should be built along the coast and in load centers. During the Eighth 5-Year Plan, we should strive to increase China's installed generating capacity by an average of more than 10,000MW a year.

Concerning the development of nuclear power, he said that the main thing at present is to quickly gain a grasp of manufacturing technology and strive to shift to domestic production of nuclear power equipment as soon as possible to reduce construction costs at nuclear power plants and create the conditions for even faster development of nuclear power during the next century.

He said that China will strengthen exploration and development of petroleum and natural gas. Petroleum exploration will gradually achieve a strategic shift toward west China.

He said we must try to increase crude oil output by 2 million tons a year during the Eighth 5-Year Plan, continue to implement policies to reduce the burning of oil, and burn 2 million tons less in oil each year.

He said that we must focus on rural energy resource and rural electrification construction and gradually solve the power supply problems of our 32 counties and population of 190 million people who do not have electricity.

While discussing S&T progress, scientific management, measures for increasing economic results and labor productivity in energy resource enterprises, and reducing environmental pollution, he said that the electric power industry should make a firm decision to abandon low efficiency, high consumption small generators and reduce the amount of coal consumed to generate power from 430 grams/kWh to about 360 grams/kWh by the year 2000.

While answering questions regarding cooperation with foreign countries in relation to China's energy resources, he said that China has already announced that 11 provinces can cooperate with foreign countries to develop energy resources. In area of cooperation between China and Taiwan to develop petroleum in the Taiwan Strait, the Ministry of Energy Resources hopes that the relevant areas in Taiwan will cooperate with mainland China for joint development. "This would have advantages for both mainland China and Taiwan".

While answering questions concerning development of oil and gas resources in Tarim Basin, Huang Yicheng said that over the past several years, with assistance from French and American geology personnel, China has invested substantial manpower and materials to explore the oil and gas resources of Tarim Basin and basically gained an understanding of the geological structure of Tarim Basin. "We plan to use Chinese equipment and manpower to develop oil deposits in Tarim Basin to greatly reduce costs. At the same time, we also desire



cooperation with other counties. The form of this cooperation will be different from the form of cooperation for risky offshore petroleum exploration".

Huang Yicheng also answered reporters' questions concerning the "Three Gorges" project and construction of new nuclear power plants. He said that these projects have not been included in the Eighth 5-Year Plan and are still in the discussion or preparation stage.

### '863 Plan' Reveals Goals of Energy Technology Strategy

916B0058B Beijing JINGJI RIBAO in Chinese  
21 Mar 91 p 1

[Article by reporter Guo Xiao [6753 2556] and trainee Chuang Xiaoqiu [7068 2556 4428]: "863 Plan Reveals Goals of Energy Resource S&T Strategy, Coal-Fired Magnetohydrodynamic Power Generation and Advanced Nuclear Power Technology Placed on the Agenda"]

[Text] By the end of this century and the early part of the next century, China will focus on research and development of coal-fired magnetohydrodynamic [MHD] power generation and advanced nuclear power technology to achieve a fundamental reversal in the backward situation of energy resource supplies. We learned this bit of news from the 863 Plan Energy Resource Technology Realm Strategic Goals Report Conference held in Beijing on 20 Mar 91.

In China's electric power industry, coal-fired power generation accounts for over 70 percent of total electric power production. Our existing coal-fired power plants have low efficiency and acute pollution and transportation problems. The relevant departments of the state have made development of coal-fired MHD power generation and advanced nuclear reactors two primary topics in the energy resource technology realm for inclusion in the state's 863 Plan in an effort to reduce our lag behind the advanced industrial nations in these two areas as quickly as possible and achieve long-term stable development of China's energy resource industry during the 21st Century.

Coal-fired MHD power generation is a new high technology that can directly convert heat energy into electric power with high power generation efficiency and conserve fuel and water. Moreover, it can be used to burn high-sulfur coal and basically eliminate pollution, so it is suitable for construction and upgrading of large basic load power plants. For this topic, a conceptual design was completed for a 10MW-grade MHD-steam combined cycle pilot power plant during the Seventh 5-Year Plan and we attacked key technical problems for the main key technologies and established a corresponding staff. We plan to complete a small-scale coal-fired MHD-steam combined cycle pilot power plant by the year 2000. After the project is completed and perfected, we will gradually expand construction and application.

Nuclear power is a commonly acknowledged as the only practical modern energy resource that can be used for large-scale replacement of conventional energy resources that is both clean and economical. Nuclear power now accounts for one-sixth of total power output in the world. The pressurized-water reactor nuclear power plants China is now building have a nuclear fuel utilization rate of only about 1 percent. Looking at the development of nuclear power, fast neutron breeder reactors, high-temperature gas-cooled reactors, and fusion technologies in basic combined fusion/fission reactors will play different roles in China's future nuclear power system and they are now in varying stages of development. During the Seventh 5-Year Plan, experts conducted intensive analysis and debate concerning development strategies and goals for these three advanced reactor types and suggested the guiding ideology of "having primary types and having starting points, coordinated development" and made gratifying progress in single item technology research, base area construction, personnel training, and other areas.

### Energy Output Shows Steady Increase in First Quarter

916B0058C Beijing RENMIN RIBAO HAIWAI BAN  
in Chinese 9 Apr 91 p 3

[Article by reporter Liang Yeqian [4731 2814 0241]: "Stable Increase in China's Energy Resource Output During First Quarter, Readjust the Industrial Structure, Develop Basic Industry"]

[Text] I learned from the Ministry of Energy Resources that during the first quarter of 1991, China produced over 232 million tons of raw coal and generated a total of more than 156 billion kWh of electric power, up by 2 percent and 9.43 percent, respectively, over the same period in 1990.

The ministry stated that China's total crude oil output exceeded 33.8 million tons and natural gas output was 3.778 billion cubic meters, up by 0.6 percent and 2.75 percent, respectively, over the same period in 1990.

During the first quarter of 1991, China's unified distribution coal mines produced over 122 million tons of raw coal, up 3.28 percent over the same period in 1990. China's hydropower generated a total of 22.05 billion kWh and thermal power generated a total of 134.7 billion kWh in the first quarter, up by 9.43 percent and 1.98 percent, respectively, over the first quarter of 1990.

The ministry stated that China's planned primary energy resource output will be 1.2 billion tons of standard coal in 1995, including 1.27 billion tons of standard coal, 155 million tons of crude oil, and 20 billion cubic meters of natural gas. Power output will be 870 billion kWh.

### All-out Effort To Develop Energy Industry

916B0055C Beijing RENMIN RIBAO HAIWAI BAN  
in Chinese 29 Mar 91 p 3

[Article by reporter Liu Luyan [0491 7627 3601]: "China Making Great Efforts To Develop Energy Resource Industry, Electric Power Is the Center, Coal Is the Foundation"]

[Text] Ministry of Energy Resources vice minister Shi Dazhen [0670 1129 2823] indicated that will continue to adhere to the principle of "electric power as the center, coal as the foundation", actively develop cooperation with economic circles in all countries, and strive to achieve a preliminary reversal of the serious shortage of energy resources and electric power within the next 10 years. He said this during a speech at the Fourth International Energy Resource (Electric Power) News Conference organized by the China International Exhibition Center and other units.

He indicated that during the Eighth 5-Year Plan, the scale of electric power construction must reach 100,000MW, with 50,000 to 60,000MW of capacity going into operation, including about 10,000MW at large and medium-sized hydropower stations and 40,000 to 50,000MW at thermal power plants that will be placed into operation. Moreover, with a focus on local investments, about 5,000MW in medium-sized and small hydropower stations will be built. By 1995, total output of primary energy resources in China will reach 1.2 billion tons of standard coal, including 855 billion kWh of power output (of which 156 billion kWh will come from hydropower). Achievement of this plan goal could produce a primary energy resource growth rate of nearly 3 percent, while the average yearly rate of growth in electric power will reach about 6.7 percent.

During the Eighth 5-Year Plan and the next decade, China's focus in the area of thermal power will be on building several power plants in coal mining regions, ports, and railway junctions. Pit-mouth power plants will include power plants in eastern Inner Mongolia, Shanxi, Shaanxi, Henan, Shandong, and the northeast China region and other pit-mouth power plants will be built in Yunnan, Guizhou, Shanxi, Gansu, Ningxia and other regions. Railway junction power plants will be built at the Fengzhen-Shacheng-Datong and Da-Qin [Datong-Qinhuangdao] railroad junctions, the Shi-Tai [Shijiazhuang-Taiyuan], Shi-De [Shijiazhuang-Dezhou], and Jiao-Ji [Jinan-Qingdao] railroad junctions, and we are preparing to build Daihai, Fengzhen, and other power plants along the Zhun-Feng [Jungar-Fengzhen] Railroad and port power plants in Liaoning, Zhejiang, Jiangsu, Shandong, Guangdong, and other provinces. Shanghai Municipality will build the Shidongkou No 2 plant, Waigaoqiao, and other power plants. In the area of hydropower, power stations and will built in the Three Gorges on the Chang Jiang, in the Hongshui He river basin, on the middle and upper reaches of the Huang He, on the Songjiang He, and in other regions. In addition,

the first through fourth phases in construction of Qinshan nuclear power plant will be built, involving a total of seven reactors for a total of 3,300MW, and several nuclear power generators will also be built in other energy-short coastal regions.

Foreign capital used to develop electric power will account for a substantial proportion in construction of thermal power plants at Ezhou in Hubei, Hejin in Shanxi, Jiujiang in Jiangxi, Sanhe in Hebei, Yanshi in Henan, Zouxian in Shandong, and others. Hydropower will include the Wuqiangxi, Ertan, Tianshengqiao, Beijing Shisanling, Tianhuangping, Longtan, and other regions, and nuclear power generators will be built in Liaoning.

### Big Growth Seen For Energy Industry

916B0058A Beijing RENMIN RIBAO HAIWAI BAN  
in Chinese 12 Apr 91 p 4

[Article: "Major Growth To Come in Energy Resource Industry"]

[Text] There will be major growth in China's energy resource industry during the Eighth 5-Year Plan. We will also adhere to the principle of combining development with conservation and place conservation in a prominent status.

According to the plan specified in the "Program", total output of primary energy resources in China will reach 1.172 billion tons of standard coal in 1995, an increase of 132 million tons over 1990 and an average yearly increase of 2.4 percent. During the 5-year period, total conservation and reduced utilization of energy resources in China will equal 100 million tons of standard coal.

By 1995, planned coal output in China will be 1.23 billion tons, up by 150 million tons over 1990. We will continue with construction of Huolinhe, Yimin, Yuanbaoshan, Jungar, and other large strip mines in Inner Mongolia, and we will build Datong mining region, Shenfu Dongsheng mining region, Tiefert and Shuangyashan mining regions in northeast China, Yanzhou, Huainan, and Yongcheng mining regions in east and southcentral China, and other large projects now under construction. We will begin construction of Huangling mining region in Shaanxi, Lingwu mining region in Ningxia, Pingshuo Anjialing strip mine in Shanxi, and other projects.

During the Eighth 5-Year Plan, China's electric power industry will implement the principle of adaptation to local conditions, simultaneous development of hydropower and thermal power, and appropriate development of nuclear power. Over 5 years, we will focus on construction of Ertan in Sichuan, Yantan in Guangxi, Manwan in Yunnan, Geheyan in Hubei, Wuqiangxi in Hunan, Yangzhuoyong Hu in Tibet, Lijia Gorge in Qinghai, and other hydropower stations and on Yimin, Yuanbaoshan, Suizhong, Shanghai Waigaoqiao, Changshu, and other thermal power plants and the second

phase of the Qinshan nuclear power project. By 1995, total power output in China will reach 810 billion kWh, an increase of 192 billion kWh over 1990.

The principle for development of the petroleum industry during the Eighth 5-Year Plan is to stabilize east China and develop west China. In 1995, arrangements for crude oil output in China are for 145 million tons. Natural gas output will be 20 billion cubic meters.

### Energy Vice Minister on Strategic Measures

916B0048B Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 31 Jan 91 p 1

[Article by staff reporter Li Gang]

[Excerpts] At the beginning of the year this reporter was delighted to learn at the National Conference of Energy Workers that the energy industry had achieved significant progress in the Seventh 5-Year Plan. The primary energy sector achieved the target of the Seventh Five-Year Plan a year ahead of time, making China a world leader in coal production. The secondary energy source, electricity, also achieved the goal of the Seventh 5-Year Plan a year ahead of schedule, ranking China fourth in the world in power generation capacity and actual power generation. Productivity in coal jumped 27 percent during this period. The 600,000-kilowatt power generators, reflecting world advanced standards in power generation, and 500-kilovolt dc power transmission projects, were completed and put into operation during the Seventh 5-Year Plan. Encouraging results were obtained in the exploration of oil in the Tarim Basin, Xinjiang Province. The nuclear power generation industry also started to develop.

Lu Youmei, vice minister of energy, told reporters that these achievements are part and parcel of the strategic measure of paying great attention to technological progress. Implementation and practice have proved that a rise in productivity in the energy industry, a rise in economic effectiveness, and a rise in safety standards are all closely linked to progress in technology.

Take coal for example. As the level of mechanization in coal mining rises from 44.98 percent to 62.92 percent, the average monthly output from the work face jumps from 11,728 tons to 15,930 tons. This means an annual increase of 100 million tons of coal from the work faces. During the Seventh 5-Year Plan period, coal output rose and material consumption fell, as did the fatality rate. To an extent, this is related to the progress in science and technology.

Now coming back to electricity. During the Seventh 5-Year Plan, advanced technology ushered in the phase of large power generation plants, large generators, and large grids. In 1985, there were only 74 200-MW generators in the nation, comprising only 20 percent of the total power generation capacity. In 1990, this number had grown to 182, or 32 percent of the total power

generation capacity. Moreover, 500-kilovolt transmission lines increased 2.85 times, compared with 1985, to reach a length of 7,239 kilometers. This new equipment is not manufactured by the Ministry of Energy but it is probably a more complicated engineering endeavor to put together all this equipment in an integrated power generation and supply system. Moreover, with the widespread use of computers, there have been new developments in the control systems of power plants, and in deployment and communications systems. It is because our full and widespread use of this new technology and skills that our coal consumption in power generation drops every year and that all our production indicators have reached new heights.

It is understood that the Eighth 5-Year Plan drafted by the Ministry of Energy calls for 1.2 billion tons of standard coal as the primary energy source for the whole nation by 1995, with an average annual increase of almost 3 percent. The annual growth rate for power generation will be about 7 percent. Oil and natural gas exploration will be strengthened. Nuclear power development will also be given high priority. This will be in addition to the basic coal and power generation infrastructure. With all this, the needs of national economic development can then be met. [passage omitted]

In 1991, over 6 billion yuan were invested in technological improvements by the energy industry, equivalent to almost one-tenth of the investment in fixed assets. At the conference, Vice Minister Shih Dazhen in his talk also touched on the key point of technological improvements. For the power generation sector, it is one of the main tasks in the Eighth 5-Year Plan and the following 10 years to systematically improve the technological standards of old power plants and to replace small plants with large ones. This is also a good path to follow in order to conserve and save energy, to save investment capital, to reduce environmental pollution, and to raise economic effectiveness.

Old low-efficiency, small steam generators will be replaced by large high-efficiency generators or heat and power cogeneration systems. The policy is to insist on "replacement or shut down." If the plant can be converted to supplying heat, then it will be converted as such. If not, the plant will be shut down altogether. The objective is not to increase power generation capacity, but to lower energy consumption and to improve environmental conditions. [passage omitted]

### Energy Ministry's 10-Year Target for Rural Power Development

916B0055A Beijing JINGJI RIBAO in Chinese 3 Mar 91 p 1

[Article by reporter Xie Ranhao [6200 3544 3185]: "Ministry of Energy Resources Decides on Goals of Struggle in Rural Power for Next 10 Years, All Counties in China To Have Power By the Year 2000"]

[Text] The Ministry of Energy Resources has decided on the goals of struggle for rural power for the next 10 years: by the year 2000, counties without power in China will be eliminated, all counties will have power, over 90 percent of peasant households will have power, and initial electrification of rural areas will be achieved.

These goals of struggle were revealed to reporters on 2 Mar 91 by director Huang Jinkai [7806 6855 0418] of the Ministry of Energy Resources Rural Energy and Electrification Department.

Statistics indicate that after more than 40 years of efforts, China has now built the world's largest scale rural power grid. By the end of 1990, China's rural areas had installed 6.30 million kilometers of high and low-voltage power grids and power use at the county level and below in China reached 200 billion kWh, equal to one-third of total power use in China.

However, due to differing economic conditions, the development situation for rural electrification throughout China is also uneven. At present, all of China's rural areas use less than 99 billion kWh of power a year and there are 32 counties and a population of 196 million people who do not have electricity. Power use levels are also very low in villages that do have power and only 12 provinces and autonomous regions supply power to 90 percent of their rural households. There are just 15 provinces in which yearly per capita power use exceeds 200 kWh.

Ministry of Energy Resources plans call for the goal of supplying electricity to all of China's counties to be achieved in two steps. We will deal first with 20 during the Eighth 5-Year Plan and the remaining 12 during the Ninth 5-Year Plan.

Huang Jinkai said that based on this plan, the Ministry of Energy Resources has arranged to build four power transmission and transformation projects in five counties without electricity: Sonid left banner in Inner Mongolia, Qira County and Kalpin County in Xinjiang, Madoi County in Qinghai, and Gerze County in Tibet. They will also build two new experimental energy resource compensation system projects in Guizhou's Xingren, Zhenfeng, and Qinglong counties, which have power shortages.

### **The Electric Power Industry in the Eighth 5-Year Plan and Beyond**

916B0056 Beijing DIANLI JISHU [ELECTRIC POWER] in Chinese No 3, 5 Mar 91 pp 2-8

[Article by Shi Dazhen [0670 1129 2823]: "Strive To Achieve Plans for the Eighth 5-Year Plan and the Next 10 Years, Continually Improve Economic Results in the Electric Power Industry"]

[Text] Abstract: This article outlines problems that exist in development of the electric power industry from the

perspective of electric power industry plans and programs, describes the basic ideology in planning work for the electric power industry during the Eighth 5-Year Plan and the next 10 years and work in several areas that must be done well in future plans and programs, such as the question of adapting the rate of growth in electric power to the rate of growth in the national economy, problems in coordinating the internal structure and proportions of the electric power industry, the question of principles for deployment of electric power projects, the question of scale economies for electric power, the question of accelerating the pace of nuclear power, issues of concern in technical upgrading of old power plants, and issues like construction schedules, construction costs, quality, and so on in capital construction in electric power.

Substantial advances were made in the energy resource industry during the Seventh 5-Year Plan (the Seventh 5-Year Plan for the national economy). Total output of primary energy resources completed the Seventh 5-Year Plan one year ahead of schedule and we moved into first place in the world in coal output. Electric power, a secondary energy resource, also was completed 1 year ahead of schedule for the Seventh 5-Year Plan, and we hold fourth place in the world in installed electric power generating capacity and power output. During the Seventh 5-Year Plan, we completed and placed into operation 600MW generators and 500 kV DC power transmission and transformation projects, which are indicators of advanced levels in the world's electric power industry, we began working on our nuclear power industry, and so on. However, to ensure sustained, stable, and coordinated development of the national economy, a rational ratio must be maintained between the rate of growth in energy resources and the rate of growth in the national economy. There are still many problems in readjustment of the internal structure, reinforcing weak links, exploiting internal potential, and other objectives in improvement and rectification of the energy resource industry. Moreover, there are extremely arduous production and capital construction tasks for the energy resource industry during the Eighth 5-Year Plan. Based on preliminary plans formulated by the Ministry of Energy Resources, the scale of electric power construction during the Eighth 5-Year Plan must reach 100,000MW and 57,000MW must be placed into operation, including 10,000MW in hydropower and 47,000MW in thermal power. Moreover, we must build about 5,000MW in medium-sized hydropower by relying mainly on local investments.

This scale of construction places substantial demands on investment in the electric power industry and it will be rather difficult to raise this much capital. Conserving capital, using investments well, and fostering better investment results will become important issues during the Eighth 5-Year Plan. These questions touch upon programs, planning, design, capital construction, and many other areas and will require close coordination



among planning, program, design, construction, equipment supply, and other units as well as good work on design ideology and design standards.

To achieve the planning objectives during the Eighth 5-Year Plan better and make even greater improvements in the electric power industry itself in the areas of economic benefits and labor productivity during the Eighth 5-Year Plan, and thereby meet the needs of national economic construction better, provide guarantees of sustained, stable, and coordinated development of the national economy, and promote improved results in the entire national economy, work must be done well in the following areas in future plans and programs:

### **I. Try In Every Possible Way To Adapt Growth in the Electric Power Industry to Development of the National Economy**

Practice and investigation indicate that to achieve sustained, stable, and coordinated development of the national economy, the elasticity coefficient of primary energy resources must be greater than 0.5 and the elasticity coefficient of electric power, a secondary energy resource, must be greater than 1. China has had a long-term shortage of electric power. The overall rate of growth for electric power over the past 10-plus years has been rapid, with total output of primary energy resources reaching 104 billion tons of standard coal in 1990, including 109 billion tons of raw coal and 615 billion kWh of electric power generated, for a 4 percent average annual increase in primary energy resources and an 8.4 percent average annual increase in electric power output. However, because the national economy has grown at an even more rapid rate, with GNP growing at an average annual rate of 7.7 percent and the gross value of industrial and agricultural output growing at 10.01 percent a year on average, the elasticity coefficient for primary energy resources and the elasticity coefficient for electric power corresponding to the rate of growth in industry and agriculture have been far below the required 0.5 and 1. As a result, the electric power shortage is still serious and it has a structural quality. The main reason is the loss of proportion for investments and a loss of coordination in the industrial structure between the processing industry and energy resources and other basic industries. For the electric power industry itself, there have been serious affects on the rational organization of its production, which has led to utilization times of power generation equipment that are too high, making economical dispatching and economical operation impossible. For this reason, we should make every possible effort in the area of plans and programs during the Eighth 5-Year Plan to adapt growth of electric power to development of the national economy and enable planned and proportional development of the electric power industry and the entire national economy. This is very important for increasing benefits in the entire national economy. Analysis of the situation over several years in China indicates that the elasticity coefficient of primary energy resources must at a minimum reach 0.5 and the elasticity coefficient of electric power must exceed 1. Based on our goal

for the next decade, that is quadrupling [the gross value of industrial and agricultural output] by the year 2000, the average annual growth rate in our GNP must be about 6 percent and the annual rate of growth in the gross value of industrial and agriculture output must be about 7 percent. Calculating based on this rate and the required elasticity coefficients as described above, the yearly growth rate in primary energy resources must be greater than 3 percent and the yearly growth rate in the electric power industry must exceed 7 percent, which means that total output of primary energy resources must reach 1.4 billion tons of standard coal by the year 2000 and power output must reach 1,200 billion kWh. Thus, in future planning and program work, we must always focus on this objective. To ensure that the ratio described above is attained, we also must make annual readjustments in implementation of yearly plans. When formulating and implementing plans, we should give full consideration to the general need for rather large investments in energy resources and other basic industries, so after state plans are decided upon, it is far more difficult to make readjustments in them compared to readjusting regular processing industry plans. Thus, we should leave some leeway when formulating plans and we must pay close attention to changing conditions in this ratio, immediately report them to the relevant departments and leaders, strive to make immediate readjustments, and enable the electric power industry to advance in accordance with the fundamental law of a socialist economy, which is adherence to planning and proportion with the national economy.

### **II. Move Quickly Toward a Rational Internal Structure and Proportions in the Electric Power Industry**

#### **A. Problems in the internal structure of the electric power industry**

These are the current problems of irrational internal structures and proportions in both primary energy resources and the electric power industry, a secondary energy resource:

#### **1. Irrational structure of primary energy resources, a proportion of hydropower that is too small.**

Of China's primary energy resources in 1985, raw coal accounted for 72.8 percent, crude oil for 20.9 percent, natural gas for 2 percent, and hydropower for 4.3 percent. Of our primary energy resources in 1990, raw coal accounted for 74.4 percent, petroleum for 19 percent, natural gas for 2.0 percent, and hydropower for 4.6 percent. The proportion of coal is already too high and continues to rise. The proportion of oil is declining, and the proportions for natural gas and hydropower are too small. Moreover, there have been no major changes for many years, which is extremely asymmetrical relative to China's abundant natural gas and hydropower resources. This irrational energy resource structure and the overly-small proportion of hydropower are creating severe problems for communication, transportation, and the

environment, and they are affecting improvement of overall social and economic results.

2. Electric power accounts for a very low proportion of ultimate energy resource consumption.

Experience in all nations of the world shows that increasing the proportion electric power in ultimate energy resource consumption is an important way to conserve primary energy resources and rationally utilize energy resources. An average of 37 percent of primary energy resources in the countries in the Organization for Economic Cooperation and Development is converted into electric power, but this figure for China is just 22 percent. In 1987, 85.8 percent of the total amount of coal consumed in the United States was used to generate power, and this figure was 73.8 percent in England, 54.0 percent in Germany, and 33.1 percent in France. China uses only about one-fourth of our 1 billion-plus tons of coal to generate power, which is 50 to 80 percent less than the economically developed nations. About one-third of China's coal is burned in small boilers and industrial boilers which have very low efficiency and cause serious pollution.

3. In our power generation equipment, the average single-unit capacity of our new generators as grown slowly.

During the Seventh 5-Year Plan, the average single-unit capacity of new generators was still less than 140MW, an increase of just 16MW over the Sixth 5-Year Plan. Originally, the plan was to use mainly 200MW and 300MW generators during the Seventh 5-Year Plan, but we actually did not do this. Furthermore, because of factors in many areas, availability rates of large generators were not very high after they were placed into operation. Moreover, China had 10,582.9MW of moderate and low-pressure generators larger than 500 kW in 1985 and this had increased to 18,761.5MW in 1989. Added to moderate and low-pressure generators, diesel generators, and so on under 500 kW, the capacity was nearly 20,000MW. The increase in the capacity of moderate and low-pressure generators has greatly reduced economic benefits in the electric power industry and coal consumption to generate power fluctuated between 398 and 398 grams/kWh from 1985 to 1989.

4. Yearly reductions in the proportion of hydropower, power transmission and transformation, and small-scale capital construction.

Although the absolute amount of state investments in hydropower and in power transmission and transformation has increased each year, because their relative proportions have declined each year, an irrational internal structure has appeared in the electric power industry. Investments in hydropower as a proportion of total investments were 33.4 percent in 1980 and 21.8 percent in 1986, and investments in hydropower are expected to account for 16.7 percent of total investments in 1990. The declining proportion of hydropower investments has prevented some hydropower projects from

organizing construction according to rational schedules and new projects have not been able to get underway on schedule. Plans for hydropower were not completed during the Seventh 5-Year Plan, and there was 2,180MW in large and medium-sized generators in the plan that did not go into operation as scheduled. The hydropower installed generating capacity as a proportion of the total installed electric power generating capacity dropped from 30.3 percent in 1985 to 26 percent in 1990 and there was a corresponding drop from 22.4 percent to 20 percent in power output. This situation has further aggravated the coal and transportation shortages. Investments in power transmission and transformation projects accounted for 20.1 percent of total investments in capital construction in 1986, but this figure dropped to about 17 percent in 1990. The declining proportion of investments in power transmission and transformation has created severe shortages of funds for construction and upgrading, especially in urban and rural grids under 200 kV. This has affected safety and economical operation and even prevented new power plants from transmitting out their power, which directly affects the returns to investments.

In 1986, 500 million yuan was invested in small-scale capital construction, equal to 3.8 percent of total investments in that year, but this declined to 1.5 percent in 1990. Seriously inadequate small-scale capital construction has led to growing deficits for educational, scientific research, and production facilities that serve power plants, employee residences, and so on, which in turn have affected improvements in production, economic results, and labor productivity.

B. Measures for rational readjustment of the internal structure and proportions in the electric power industry

A rational structure and proper proportions in the electric power industry generate huge economic benefits. This requires us to focus on work in the following areas during the Eighth 5-Year Plan:

1. We must increase the proportion of electric power in ultimate consumption of energy resources.

Practice in China and foreign countries has shown that the greater the proportion of electric power consumption as a part of the ultimate consumption of energy resources, the higher the extent of electrification and the lower the energy consumption. Analysis of the United States from 1960 to 1982 indicates that a 10 percent increase in the amount of electric power consumed per unit of industrial value of output reduced energy resource consumption by 41 percent. For this reason, we must try to convert more coal into electric power instead of burning it directly as fuel. About 25 percent of our coal now goes to generate power and plans call for increasing this to 29 percent in 1995 and 33 percent in 2000, meaning that one-half of additional coal output will be used to generate power, which is extremely necessary.

2. Prohibit the development of small condensed steam thermal power and oil-fired generators in large grids.

We must reinforce industry management and resolutely implement the spirit of the State Council's "Notice Concerning Adherence to State Industrial Policy To Reinforce Management". In the future, all new construction, expansion, or upgrading of condensed steam thermal power generators and oil-fired generators smaller than 25MW (including gas turbine generators), regardless of their jurisdictional relationships and investment channels, regardless of whether they involve new construction or expansion or the size of the scale of upgrading, every electric power bureau of the province (municipality, autonomous region) in which they are located should meet with the initial examination and report department of their planning commission to strictly do the examinations according to capital construction procedures, and they should clear up project proposals and design task documents already approved by all departments.

3. Strive to increase the extent of hydropower development, make good arrangements for ratios among large, medium-sized, and small hydropower and ratios between hydropower and thermal power.

To accelerate hydropower construction and increase the degree of hydropower development we should first of all solve the problem of construction capital, try in every possible way to raise capital and accelerate the establishment of hydropower capital construction funds, meaning that within the scope of the 0.02 yuan requisitioned per kWh of power, another 0.01 yuan should be requisitioned for use as a hydropower development fund. We plan to do work in two areas at present. One is organizing several provinces (autonomous regions) to raise capital for building hydropower stations in accordance with the principle of integrating the planned economy with market regulation. Examples include the electric power joint venture company organized by four provinces (autonomous regions) in south China (Guangdong, Guangxi, Guizhou, and Yunnan), the capital raised for construction of Lijia Gorge hydropower station by fourth northwest China provinces (autonomous regions), the Wu Jiang Basin Hydropower Development Company, and so on. The second is to invest one-half of the existing administrative capital the state has arranged for electric power in hydropower construction. We will use these two methods to increase investments in hydropower construction, accelerate the pace of hydropower construction, and quickly reverse the growing trend toward declining proportion of hydropower. While developing large-scale hydropower, we also should work hard to support medium-sized hydropower and be concerned with a rational proportion among large, medium, and small-scale hydropower and an appropriate proportion of hydropower with different regulation capabilities. We also should be concerned with a proper ratio between hydropower and thermal power within a particular grid to prevent excess loss of water during the rainy season and serious loss of power

during the dry season. These directly affect returns to investments and the fostering of the economic benefits for all of society.

4. Gradually increase the proportion of investments in power grids construction.

Based on China's experiences in construction over many years and an estimation of the scope of existing state investments in construction, the rational ratio of investments in power transmission and transformation and in grid construction to overall investments in electric power construction should be 2:8, meaning that about 20 percent should be invested in power transmission and transformation, but this figure has now dropped to 15 percent, and we urgently need to reverse this as quickly as possible. For this reason, we should try to arrange for more investments in power transmission and transformation in yearly plan arrangements. We should focus first on power source transmission projects and prevent power backups. Second, we should reinforce planning and optimized design of 200 kV power grids and overcome weak links in grids. Third, we should reinforce upgrading in urban and rural grids to strengthen the safety, operational economy, and dispatching flexibility of grid power supplies, produce better returns to investments in electric power construction, and reduce power supply losses in grids. In another area, full consideration should be given to controlling the ratio of property rights of other enterprises and departments outside of departments in arrangements for investment in grid construction. In principle, ownership rights and property rights over grids should be entirely under ownership by power management bureaus and provincial electric power bureaus to ensure grid unity. For this reason, the capital invested in electric power construction should be raised completely by state investments and capital raised by the electric power industry itself. Grids built by other enterprises and departments should gradually be turned over to ownership by power management bureaus through the repayment of principle and interest or leasing and placed under unified management.

5. Gradually increase the proportion of power plants directly managed by grid management bureaus.

To ensure unified dispatching in grids and enable them to maintain grid stability when dealing with accident emergencies and quickly regulate power exchanges between two provincial grids and between two large regional grids, we must strengthen and increase the capacity of power plants under direct management and direct dispatching of power grid management bureaus. The proportion of this capacity is too small at present, especially in the Central China Grid and East China Grid, so plans should arrange to give grid management bureaus direct responsibility over construction and management of one or two large power plants in each large regional grid. In addition, plans should strive to obtain state permission and agreement for all provincial bureaus and grid management bureaus to sell electric power construction bonds, and the property rights and

management rights over the power plants built using these bonds should be directly administered by grid management bureaus to make grid management bureaus stronger.

### III. Arrange Electric Power Industry Construction Projects According to the Principle of Optimized Resource Deployments

In electric power system plans, the overall grid should be used for consideration of the distribution of power source sites and grid construction. In a situation of provinces "dividing up the stoves to eat" [dividing control over resources] and investment diversification, however, local areas think of their own provinces when investing in power plant construction and very few consider conformity to the principle of investment optimization. An example is Shuangliao power plant, where it can be said that expansion of Tongliao power plant was the most beneficial, but Jilin Province was unwilling. Another example is the four power plants built relatively close together at Yangluo, Hanchuan, Ezhou, and Huangshi in Hubei Province. Relatively speaking, the returns to their investments were rather poor.

Moreover, between coal and power, all cases where conditions permit should implement joint administration of coal and power, unified planning and unified design for coal and power, and simultaneous construction. This can conserve investments and operating expenses and produce the best returns to investments. There were very few projects of this type during the Seventh 5-Year Plan, however, and the Yimin coal-power joint venture has just gotten underway. More commonly, each is handled separately. An example is Huichun power plant and East Huichun coal mine in Jilin Province, where the power plant and coal mine are just 800 meters apart. A special dedicated railroad was built and they had to build redundant facilities for car loading and unloading. This increased capital construction investments and operating expenses.

For coal mines, hauling high heat value coal to power plants after the coal is dressed can lessen the burden on railway transport and reduce wear on boilers and other equipment, increase useful lifespans, and permit construction of fewer ash yards, so the economic benefits are apparent. Because of problems in investment allocations during the Seventh 5-Year Plan, however, this basically was not considered.

In planning and program work, we must conscientiously study principles and policies, adhere to the principle of integrating the planned economy with market regulation, respect the economic system and operational mechanisms required for development of the planned commodity economy, apply economic methods and economic levers to overcome departmental separation and isolation, break down regional closure, promote the formation and development of a unified national market, promote the organic integration of national unity with local and departmental uniqueness, and make

plant site selection for power sources truly conform to the principle of optimized resource deployments. Only in this way can we foster the best returns to investments.

#### A. Power source programs must stress the principle of "unified grids"

Programs must be developed according to resource conditions and characteristics of the forces of production and on the basis of the three levels of national grids, large regional grids, and provincial grids, and overcome the scattered situation of provinces fighting for themselves and prefectures, cities, and counties fighting for themselves. For this reason, we must deal with the current characteristics of investment diversification and formulate rational economic policies based on the economic system of a planned commodity economy. For example, implement five divisions for each investment department, meaning division of property rights, division of value of output, division of output, division of profits, and division of taxes. In this area, we should focus on making good arrangements in the program for joint power development by four provinces (autonomous regions) in south China to transmit power to Guangdong, centralized construction of Yiming and Huolinhe coal-power base areas in eastern Inner Mongolia to transmit power to all areas of northeast China, construction of power plants in Shanxi to transmit power to east China, construction of power plants in northern Henan to transmit power to Hunan, Hubei, and Jiangxi, construction of power plants in western Inner Mongolia to transmit power to the Beijing-Tianjin-Tangshan region, and so on. This sort of configuration is far more rational than shipping lignite from Yimin or Huolinhe to power plants built in Harbin and Changchun, or transporting coal from Inner Mongolia to power plants built around Beijing. The economic, social, and environmental benefits are quite apparent.

#### B. Where the conditions permit, we must try as much as possible to achieve integrated administration of coal and power

The first thing involved in joint administration of coal and power is unified programs, unified planning, and simultaneous construction of coal and power. In management, this means working according to actual circumstances, meaning that there can be either intensive or loose economic contractual relationships. This can conserve investments and operating expenses and provide better investment results. The focus during the Eighth 5-Year Plan should be on good construction of Yimin, Huolinhe, Jixi, and other coal-power joint ventures, and we should explore joint capital raising by multiple parties at coal mines and power plants to build coal dressing plants to raise the heat value of the coal used at power plants. This type of investment can provide benefits for many parties. It can: 1) reduce pressures on railway transport, 2) reduce the dimensions of power plant boiler equipment and reduce the weight and manufacturing costs of boilers, 3) reduce investments in power plant coal supply system facilities, 4) reduce wear on boiler



pulverizing system equipment, which would lengthen the useful lifespans of equipment, reduce the amount of maintenance work, and reduce power generation costs, 5) reduce the capacity of ash yards and reduce investments, and 6) reduce fly ash and environmental pollution.

Utilizing coal gangue to generate power and supply heat can provide power and heat supplies for mining regions, with substantial economic and environment benefits, and we will support this. Consideration can be given to these investment sources to build coal gangue power plants: 1) arrangements in energy conservation investments; 2) arrangement of a portion of investments in coal and electric power and the coal that is conserved. For coal mines, this can replace output. For the electric power system, this can increase installed generating capacity and the investors can receive the benefits of this portion of coal indices or power plant capacity.

#### **IV. Show Conscientious Concern for Scale Economics in Power Source Construction**

In power source programs, we hoped that 200MW and 300MW generators could be the main force in the Seventh 5-Year Plan and requested the construction of one 4 X 300MW or 4 X 600MW power plant, but due to difficulties in raising capital and excessively decentralized capital that required centralization to build large power plants and the lack of corresponding policies that could be accepted by all parties, this undoubtedly formed a situation in which provinces fought for themselves, so more power plants installed 125MW and 200MW generators. The result was a failure to form definite "scale economies" and a failure to obtain the benefits of "scale economies".

Even more serious was that because of severe power shortages in all regions over the past several years, they all thought of developing power within their own jurisdictional scopes, so several regions built quite a bit of small hydropower and small thermal power within the scope of coverage by large grids. Small thermal power generators increased from about 12,000MW in 1980 to about 20,000MW in 1989. At the same time, they were also subjected to the effects of various factors which meant that several high efficiency generators generated insufficient power while small, low-efficiency generators generated too much power, which created considerable waste.

The development of modern industry toward large scales and groups is a universal law in world economic development. Power construction also conforms to this sort of law. This is especially true for China's multi-province grids which have reached capacities in excess of 20,000MW. Thus, using advanced S&T achievements to build large 3,000 to 4,000MW power plants has extremely great advantages for improving economic benefits, reducing energy consumption, and reducing costs to the greatest possible extent. In this area, the first thing

is to have a clear understanding in ideology. Furthermore, achieving scale economies requires centralization of capital as well as matching policies, which means enabling each unit that makes a joint investment in construction to receive greater benefits than they would have if each unit built small-scale power plants. This work will also be the focus on future planning work.

Based on the Eighth 5-Year Plan and the program for the next 10 years, we should make arrangements in annual electric power plans to build over 10 large thermal power plants and hydropower stations with capacities of about 3,000MW

#### **V. Accelerate the Start of Nuclear Power**

Nuclear power got under way in the Seventh 5-Year Plan. The original plan was for the first phase 300MW generator at Qinshan to go into operation during the Seventh 5-Year Plan but this was delayed for various reasons, and the start of the second phase at Qinshan has been delayed because of programs, capital sources, and other problems. The basic reason is that although technical lines for nuclear power construction have been unified, there is still no unified understanding of the urgency of starting on nuclear power, truly raising nuclear power to an important position in state energy resource construction, and the need to concentrate forces in the areas of manpower, materials, and finances to fight a war of annihilation, and measures have been ineffective.

The main things in the nuclear power industry are to accelerate construction of the first and second phases at Qinshan and achieve a shift to domestic production of 600MW nuclear power generation equipment as quickly as possible. The main problem at present is insufficient construction capital and unstable sources. The way out is one, rely on state support, and two, have all local areas raise capital for construction. Corresponding to this, market economy mechanisms should be brought in to regulate nuclear power construction and the operational management system. We also must focus on nuclear power project construction using imported equipment from foreign countries at Daya Bay and Liaoning to enable China's nuclear power to truly get under way during the Eighth 5-Year Plan and enable it to take larger steps.

#### **VI. Technical Upgrading Should Become the Order of the Day**

For the electric power industry, planned technical upgrading in old power plants and replacing small-scale equipment with large-scale equipment is a primary task in the Eighth 5-Year Plan and the next 10 years. This is also an important technical measure for conserving energy resources, conserving investments, reduce environmental pollution, and improving economic results.

The main form of technical upgrading in old plants is using large-scale high-efficiency generators or heat and power cogeneration generators to replace low efficiency

or pure condensed steam operation generators in old plants. Resolutely "combine upgrading and shutdowns", shift to heat supplies for those that can be converted to heat supplies and resolutely shut down those that cannot be converted to heat supplies. The main goal in upgrading is not expanding capacity and generating a little more power. Instead, it is reducing energy consumption and improving the environment. This can also reduce construction costs compared to building new power plants and is better for employee arrangements. The biggest problem in upgrading old plants is that capital source channels have not been opened up. Thus, we must do good upgrading programs and preparatory work, and we must raise capital through many channels like we do for capital construction for electric power. The first thing is to provide funds for loans for technical upgrading, provide funds for local areas, make loans for energy conservation, and make arrangements in capital construction. Try to upgrade Baima, Chongqing, Luoyang, Buxin, Xiguan, Xigu, Yangshupu, and other power plants during the Eighth 5-Year Plan for a total of about 5,000MW.

**VII. In Capital Construction, Strive To Shorten Construction Schedules, Reduce Construction Costs, Improve Quality, and Generate Better Investment Results**

The overall cost of electric power capital construction in China has grown rather quickly, rising from 1,750 yuan/kW in 1985 to 3,000 yuan/kW during the Seventh 5-Year Plan, an average yearly increase of 11 percent. The main reason was materials price factors, but it was also related to overly-high construction standards, excessive land occupation, and so on.

As mentioned previously, based on the scale of construction during the Eighth 5-Year Plan, the investments in electric power industry construction during the Eighth 5-Year Plan will be enormous and it will be very hard to raise this much capital. We must try in every possible way to conserve investments, reduce construction costs, and increase the benefits of capital utilization. For this reason, we must focus on doing good work in the following areas in the future:

**A. Do good preparatory design work, and in particular reinforce geological prospecting work**

Preparatory expenditures on hydropower are insufficient, surveying and design have become more difficult, and it is very hard to raise capital for construction of several large hydropower stations. This created the need to reduce preparatory project reserves for hydropower and an inability to satisfy development plans during the Seventh 5-Year Plan. Thus, we must focus on doing good preparatory design work, create convenient conditions for construction, try as much as possible to create the prerequisite conditions in designs to reduce the amount of construction engineering, and select equipment that has passed the test of operational practice and that is reliable.

**B. Do good preparatory work in advance of construction**

Truly work in accordance with state requirements. Besides doing the "three openings and one leveling" well, investments, equipment, staffs, technical equipment, and so on must all be implemented in turn and they must enable continuous construction before plans can be formally reported and construction can formally begin.

**C. Concentrate forces to fight a war of annihilation**

Organize construction on the basis of rational construction schedules, and in particular centralize capital utilization to enable projects to "eat their fill". We cannot work on every project at once, because the result is that "no one can eat their fill" and none can move forward quickly. Every province (autonomous region) that wants to begin a project must get in line. A province (autonomous region) cannot build several projects at once, because the result is that investments are scattered and none can move forward quickly. Moreover, there should be a single plan for four or six generators for a power plant and continuous construction. Preparatory work must be done in one try, and construction staffs cannot be shifted back and forth. This can shorten overall construction schedules, reduce construction costs, conserve investments, and accelerate the pace of projects. We also must rely fully on local areas and try to obtain major support from local leaders. Full consideration should be given to ways to motivate local initiative in organizational leadership, management systems, and allocation of benefits.

**D. Bring in competitive mechanisms, solicit bids where conditions permit**

Equipment ordering must be done under plan guidance through bid solicitation to bring in competitive mechanisms to improve equipment quality and equipment completeness, increase equipment supply assembly rates, accelerate construction progress, and reduce construction costs to ensure that favorable conditions are created for quality after going into operation. There are different viewpoints at present concerning whether or not there should be solicitation of bids for primary equipment. We should use propaganda and concrete examples to persuade the relevant areas to continually perfect bid solicitation work and organically integrate the planned economy with market regulation. We should gradually try to move toward integration of the planned economy with market regulation in selecting design and construction units.

**E. Strive to shorten construction schedules**

The following demands were set forth in the Eighth 5-Year Plan: reduce the construction schedule to 24 to 30 months from the time main project construction begins until the first generator goes into operation for thermal power plants of about 2 X 300MW; reduce the construction schedule to 2 to 4 years from the time that

the flow is diverted until the first generator goes into operation at large and medium-sized hydropower stations.

#### F. Design standards should be adapted to China's national conditions

To reduce construction costs, we also must adopt moderate-level appropriate standards under the prerequisite of ensuring safety and economic production. We must conscientiously do good evaluation work after power plant construction, immediately summarize experiences and lessons, and absorb advanced experiences in foreign designs. We certainly must give primacy to conservation in land use, conservation in water use, conservation in coal use, and reduced construction costs. We must reduce unnecessary areas around large plants, large plant buildings, large glass windows, large repair and maintenance yards, large office buildings, rather large-scale repair and assembly workshops for several plants in the same region, overly-high automatic control standards that do not conform to China's national conditions, overly-large reserve equipment capacity, "connecting buildings", leading high consumption living facilities, and so on. Some should be eliminated and design personnel should strictly control these things for the state according to estimated budgets.

#### G. Reinforce management by quotas

This includes design quotas, construction quotas, and production consumption quotas (amount of manpower and materials consumed). Good work should be done in formulating and revising quotas to maintain their advanced qualities and gradually achieve the use of quotas as evaluation indices and yardsticks for the formulation of plans, designing, project construction, production management, and cost accounting.

In summary, to accelerate development of the electric power industry, we must one, increase investments in the electric power industry, and two, try in every possible way to use investments well and make an effort to give full play to the benefits of capital. There is considerable potential in this area. By mobilizing the masses, keeping careful accounts, and undertaking reform, we certainly will make outstanding achievements in the areas of capital construction and improving economic results.

#### Energy Prospecting Has Top Priority

916B0048A Beijing RENMIN RIBAO HAIWAI BAN  
in Chinese 22 Feb 91 p 1

[Excerpts] Zhu Xun, minister of geology and mineral resources, pointed out that the mining industry is the cornerstone and pioneer of basic industries. In order to ensure the realization of the strategic goals of the second phase of China's economic development, he added, the Ministry of Geology and Mineral Resources, during the Eighth 5-Year Plan, will raise the research level of China's geological studies, realize the important breakthrough of finding mineral resources by studying the

geological structure, provide new reserves for badly needed minerals for economic development, reinforce geological work in key areas for serving the needs of agriculture, energy, raw materials, and transportation. [passage omitted]

According to Minister Zhu, the Eighth 5-Year Plan goals call for additional reserves in mineral resources as follows: 20 billion tons of coal, 800 million tons of iron ore, 800 million tons of phosphates, 370 million tons of sulfide ore. Moreover, exploration and prospecting of energy resources will be placed on top of the priority list. This is particularly so in oil and natural gas exploration, where exploration work will be accelerated in the Tarim Basin and in the East China coastal area, and the survey and exploration of Karst, and Southern carbonate areas for oil and natural gas and coal-produced gas. At the same time, China will raise the level of study of the geology of the nation. Regional geological surveys on a scale of 1:50,000 will be completed on a total of 500,000 square kilometers of land and regional geological surveys on a scale of 1:200,000 will be completed on a total of 260,000 square kilometers. A consolidated oceanic geological survey, geophysical survey and a general survey of mineral resources will be carried out.

The mining industry will carry out a comprehensive survey on geological environment and geological disasters, monitor and supervise management work, devise a consolidated conceptual framework for the geology and environment of key rivers, key communications trunk routes, key cities, key engineering projects, and key mines, and carry out a general survey on geological disasters. Monitoring and forecasting of geological disasters will be started and phased in to raise the capability to survive or prevent geological disasters. [passage omitted]

During the Eighth 5-Year Plan, the mining industry will open itself to foreign countries and strengthen cooperation with foreign countries. Minister Zhu Xun also disclosed that the Ministry of Geology and Mineral Resources will start a comprehensive program of cooperation and exchange with foreign countries at the technological and economic level in certain key areas. Geological survey units and enterprises will further develop labor management, technology, and equipment and the export of mineral resources.

#### Nation's Petroleum Technology Approaches World Level

916B0052A Beijing RENMIN RIBAO in Chinese  
8 Feb 91 p 1

[Article by reporter Wu Chunzhong [0702 4783 1813]: "China's Petroleum Science Research Moves Toward the World, Soviet and Venezuelan Experts Commend China's First-Rate Technology"]

[Text] China's petroleum science research has taken a big step towards the world. The Petroleum Exploration and Development Scientific Research Academy and

other units in the first group to provide scientific research services to the outside world have received good evaluations from their counterparts in six cooperative projects with the Soviet Union and Venezuela.

During the Seventh 5-Year Plan, the Petroleum Science Academy took on its first two scientific research tasks for Venezuela in conjunction with Daqing and Huabei [North China] oil fields, opening the first page in the movement of our petroleum science research toward the world. Beginning in 1988, they also joined with Huabei, Sichuan, Daqing, and other oil fields in four cooperative petroleum and natural gas exploration and development projects with the Soviet Union. In consulting on compilation and readjustment of water injection programs and oil field development in Venezuelan oil fields, because all of the Chinese units worked cooperatively, extremely satisfactory results were obtained in using development, geology, lithophysics, oil pool engineering, well logging, numerical simulations, and many other disciplines for cooperative research. Venezuelan experts said in praise that "Chinese consulting was very satisfactory and the water injection readjustment program compiled by Chinese experts was at international levels".

In the four cooperative projects with the Soviet Union, the Petroleum Science Academy's organization of high-level forces and the very detailed work of all comrades fully revealed China's superiority in seismic data interpretation, logging interpretation, compilation of condensate gas field development programs, oil deposit numerical simulation, and other areas of research and in geology and development of chemical experiment and analysis measures, which led to satisfactory results in all the cooperative projects. The Soviets highly commended the professional levels, work attitudes, and management levels of their Chinese comrades and felt that "development of China's petroleum industry has been amazing and the levels of expert personnel are first-rate".

#### **The Loess Plateau: New Energy Base of Next Century**

916B0052D Beijing RENMIN RIBAO HAIWAI BAN  
in Chinese 6 Mar 91 p 4

[Article by reporter Kong Xiaoning [1313 2556 1337]: "A Comprehensive 5-Year Survey Indicates that the Loess Plateau is China's Main Energy Resource Base Area"]

[Text] Over 300 experts spent 5 years in completing a comprehensive research survey which indicates that the loess plateau region, the birthplace of ancient Chinese civilization, will soon become China's most important energy resource and raw materials base area. Development and construction of this region will place a decisive role in China's economic invigoration.

The loess plateau covers an area of about 480,000 square kilometers, most of it in the middle and upper reaches of the Huang He.

Beginning in 1985, the Chinese Academy of Sciences and State Planning Commission Natural Resources Comprehensive Survey Commission organized a scientific survey team to use aerial and space remote sensing and other advanced technology for a comprehensive survey on an unprecedented scale of the loess plateau region. In 1986, this major research topic was included as a major state project to attack key S&T problems during the Seventh 5-Year Plan.

The survey report recently completed by the experts points out that the potential value of important minerals in the loess plateau accounts for over one-half the total in China, that it has over 70 percent of China's coal resources, 95 percent of our rare earths, and 58 percent of our bauxite, and it holds an important place in molybdenum, copper, lead, zinc, iron, and so on.

The experts predict that by the year 2030, this region will account for 70 percent of China's total coal output, one-fourth of our installed power generation capacity, and over one-half of China's output of many non-ferrous metals and chemical industry raw materials products. Achievement of China's economic construction objectives in the future will depend to a substantial degree on construction of the loess plateau region into an energy resource and heavy and chemical industry base area.

On the basis of a comprehensive survey of the resources, environment, economy, society, and other aspects of the loess plateau region, the experts have established a territorial resource database and information system that is providing advanced measures and scientific reserves for comprehensive administration and development and for planning and decision making in this region.

#### **China Now World's Top Producer of Raw Coal**

916B0052B Beijing RENMIN RIBAO in Chinese  
9 Mar 91 p 1

[Article by Xie Yang [3610 7122] and Ji Sheng [3444 3932]: "China Now World's Leader in Raw Coal Output, 220 New Mineshafts Constructed and Placed into Operation in 10 Years, Main Task Now Is To Improve Coal Quality and Reduce Enterprise Losses"]

[Text] After 10 years of reform, China now has the world's largest scale coal industry and a solid foundation has been laid for a takeoff in our national economy during the 1990's. During the Eighth 5-Year Plan and the next 10 years, the coal industry must establish a concept of the overall situation and combine protecting the completion of state production plans with maintaining reserve strengths and healthy development of coal mines. This was proposed by Ministry of Energy Resources vice minister Hu Fuguo [5170 1381 0948] at the China Unified Distribution Coal Mine Corporation Work Conference held in Beijing on 8 Mar 91.

Over the past decade, China has completed and placed into operation 220 directly-administered and direct-supply mineshafts which added 175.63 million tons in new production capacity. Through the efforts of China's 7 million coal miners, our goal of 1 billion tons in yearly raw coal output was achieved 1 year ahead of schedule and our raw coal output reached 1.08 billion tons in 1990, first place in the world. Coal exports in 1990 were up 2.8-fold over 1980 and it became one of China's ten top foreign exchange earning export industries. However, the coal industry also faces difficulties and problems like serious losses, capital shortages, poor enterprise results, severely inadequate reserve strengths, an urgent need to improve the external environment, and so on. Hu Fuguo said that if we wish to solve these problems and achieve sustained, stable, and healthy development in the coal industry, we must first foster the "spirit of rock sections" and try in every possible way to exploit internal potential. We should speed up construction at mines now being built and try to form comprehensive capacity as soon as possible. With a prerequisite of trying to get the state to stabilize and increase investments, we

should expand the scale of construction when appropriate and accelerate development and construction of open-cut coal mines.

Hu Fuguo pointed out that the main tasks at present are to improve the quality of coal products and reduce enterprise losses. We should solve the problems of improper quality grades and tons of losses, eliminate direct sales of raw coal, and focus on major loss operators during 1991 and 1992. We also should focus on several models with good production conditions, good geographical locations, good coal quality, good coal sales, and outstanding benefits. We should cease production at a few mines with very poor conditions, limited coal output, poor sales, and substantial losses and their output responsibilities should be assumed by mines with good results that produce in excess of quotas. We should use marketing as a tap and quality and product variety as the root, rely on S&T progress, accelerate the pace of reform and opening up, improve the quality of organs and staffs, and organize coal production well.



### Supply and Demand Situation in East China Grid

916B0045A Shanghai JIEFANG RIBAO in Chinese  
28 Jan 91 p 3

[Article by Wang Youcheng and Hu Weiqiang]

[Excerpts] This year the relationship between power generation and power consumption in the East China Grid will become more acute than last year. This is the message from the working meeting yesterday of the East China Grid.

With the turnaround and rapid acceleration of industrial production, the Municipality of Shanghai, and Jiangsu, Zhejiang, and Anhui provinces—all under the jurisdiction of the East China Grid—will see a significant increase in power consumption and demand. On the basis of the planned industrial production growth provided by the various cities and provinces, it is forecast that total power consumption from the grid for this year will be about 117 billion kilowatt-hours, a 6.75 percent increase over that for last year; and daily peak load will reach 16 million kilowatts. The shortfall is 3.13 billion kilowatt-hours and power load shortfall is 1 million kilowatts. The power and load shortage problems will impact mainly in the second and third quarters of this year. It is difficult to control the power consumption by subscribers and the time frame they consume power and also difficult to even out the power consumption, with a peak-and-valley difference of as much as 5 million kilowatts. Therefore the safe and stable operation and the quality and quantity of power generation are threatened.

In the working meeting of the East China Grid, experts pointed out that in the face of these difficulties, [passage omitted] work must be accelerated on the seven large-and-medium generators (total generating capacity: 1.6 million kilowatts) planned to be put into operation this year. It is also necessary to assure that the quality and quantity of power will be balanced. It will be necessary to reinforce and streamline management, assuring that power generator inspection and maintenance is done in a rational and coordinated manner and to reduce emergency unscheduled shut-downs for repair. It is also necessary to assure stable, full-capacity power generation. Arrangements should be made for the distribution of load for the peak power consumption seasons in order to maintain and assure the quality and quantity of power. [passage omitted] In the event of power shortage and emergency, the three provinces and one city will help each other to assure safe and stable operation of the grid. [passage omitted]

### Rapid Development of Xinjiang Power Industry Reported

916B0045B Urumqi XINJIANG RIBAO in Chinese  
18 Jan 91 p 1

[Excerpts] The Xinjiang power industry, which is closely related to the region's industries, agriculture, and people's livelihood, saw rapid development during the Seventh 5-Year Plan. Power generation engineering projects

were completed and became operational in areas north and south of Tian Shan. By the end of 1989, power grids of 110-kilovolts or more, such as Urumqi-Shihezi, Korla, Yinli, Tacheng, Hami, Kashi-Atushi, and Karamay, had been completed. Moreover, the 220-kilovolt mainstay of the Urumqi-Shihezi grid was completed. [passage omitted]

In the four years prior to this year (during the Seventh Five-Year Plan), 2.413 billion yuan was invested in power generation work, or 3.6 times the amount for the Sixth 5-Year Plan. Some 906 million yuan, or 79.7 percent of the total investment, was investment on thermal electric generation. During the Seventh Five-Year Plan, power generation capacity increased by an additional 535,200 kilowatts, a growth of 83.3 percent over the figure for the Sixth Five-Year Plan. In particular, after facilities such as MANAS No. 1 and No. 2 (200,000 kilowatts), Hami No. 2 (24,000 kilowatts), Tacheng (24,000 kilowatts), Kangsu (12,000 kilowatts), and Hetian (12,000 kilowatts) became operational, the acute power shortage was greatly reduced. [passage omitted]

During the Seventh 5-Year Plan, the whole area's power generation is estimated to reach 27.65 billion kilowatt-hours, an increase of 76.4 percent over the Sixth 5-Year Plan. In 1989 alone, total power generation reached 6.299 billion kilowatt-hours, making 1989 the year of highest growth in power generation in 10 years for the autonomous region. [passage omitted]

### Hubei Planning Hydro, Thermal Power Facilities

40100042A Beijing CHINA DAILY (Business Weekly)  
in English 15 Apr 91 p 1

[Article by staff reporter Huang Xiang: "Hubei Plans Three Power Plants"]

[Text] Central China's Hubei Province—with the proposal for the mammoth Yangtze Gorges hydro project still unresolved—will launch three major power projects to satisfy local needs in the next five years.

The three undertakings, 3.24 million kilowatts in total designed capacity, are also part of the province's latest effort to develop the abundant water resources within Hubei and the coal deposits in neighbouring regions, according to Hubei Governor Guo Shuyan.

New estimates put Hubei's exploitable water resources at 284 million kilowatts, ranking it fourth in China which itself boasts the world's richest hydraulic resources.

If all these potentials are tapped, Guo said, annual electrical generation will amount to 149.35 billion kilowatt hours, or the equivalent of 60 million tons of standard coal.

Already the nation's leading hydropower supplier, Hubei has witnessed the full commercial operation of three

major stations and the partial completion of the 1.2-million-kilowatt Geheyan project.

Guo said it is only 50 kilometres away from Geheyan on the Qingjiang River in western Hubei that Gaobazhou, the planned water power project, will be located.

The project is actually part of the province's development scheme on Qingjiang River, an important tributary of the Yangtze River which passes through central Hubei.

With a designed capacity of 240,000 kilowatts, the project will generate 890 million kilowatt hours of electricity a year upon completion.

But Guo said it is still not decided when construction is to start, despite the fact that the scheme has been included in the provincial Eighth Five-Year Plan (1991-95).

According to Guo, the other two power undertakings will be of coal-fired plants using coal deposits outside the coal-short province.

Coal reserves are scarce in Hubei. But a short distance and good transport to coal-producing regions will make up for that, he said.

Said Guo: "Two major railway trunklines and the great Yangtze provide Hubei easy access to such coal suppliers as Shanxi, Shaanxi and Henan provinces."

The two coal-fired plants have a combined capacity of 3 million kilowatts, "enough to satisfy the expected increase of power consumption during the next few years," the governor said.

Construction of E'zhou Power Plant, the smaller of the two, is partially funded by a Japanese loan and due to start later this year.

The exact date to start construction on the other plant is still under discussion. But Guo said it should be started between 1994 and 1995.

Guo also said construction of power networks must also be quickened to cope with the planned installation of power generating units.

## Overview of 10-Year Hydropower Development Program Presented

916B0054A Beijing SHUILI FADIAN [WATER POWER] in Chinese No 2, 12 Feb 91, pp 3-7

[Article by Pan Jiazheng [3382 1367 6927], chief engineer in the Ministry of Energy Resources: "China's 10-Year Plan for Hydropower Construction, Problems that Exist, Directions of Struggle"]

[Text]

### I. Hydropower Construction in the Eighth 5-Year Plan and the 10-Year Plan

Only the final 10 years remain between now and the end of this century. This will be a decade of battle and the most decisive decade in achieving strategic deployment of the development of China's economy.

The state is now arranging the Eighth 5-Year Plan and formulating a 10-Year Plan. Planning departments and relevant units in the Ministry of Energy Resources are also doing a great deal of work to formulate plans and programs for future hydropower construction. Although there is not total unanimity among the programs envisaged by all units, there is consensus on the overall outline.

At the end of 1989, China's total hydropower installed generating capacity was 34,580MW (at full bore) and yearly power output was 118.5 billion kWh, equal to 27.3 percent of China's total installed generating capacity and 20.2 percent of our total power output, and comprising 9.1 percent and 6.1 percent, respectively, of our developable hydropower resources. It is apparent that the degree of development is very low, but we hold 6th and 5th places in the world in gross values, respectively.

By the end of 1990, the projected hydropower installed generating capacity may reach 35,300MW and yearly output may surpass 123.0 billion kWh. Because the increase is not that great in absolute terms, hydropower as a proportion of all of China's electric power will drop further. It should be pointed out that during the Seventh 5-Year Plan, China's electric power construction and production were completed in excess of quotas but hydropower construction fell far below completing plans. Plans called for adding 8,210MW in hydropower during the Seventh 5-Year Plan but we actually completed only 6,000MW, just 73 percent of the plan and we had to depend mainly on construction of thermal power in excess of plans. This situation and trend deserves our attention.

During the next 10 years, information from the Planning Department in the Ministry of Energy Resources indicates that plans call for an additional 45,000MW or so in hydropower, including about 28,000MW in large and medium-sized conventional hydropower stations (9,790MW in the Eighth 5-Year Plan and 17,980MW in the Ninth 5-Year Plan) included in state plans (the Three Gorges was not included because the project requires

special consideration); about 6,000MW in pumped-storage power stations (1,770MW in the Eighth 5-Year Plan and 4,260MW in the Ninth 5-Year Plan); about 5,000MW in local medium-sized hydropower (2,000MW in the Eighth 5-Year Plan and 3,000MW in the Ninth 5-Year Plan); and about 6,000MW in small-scale hydropower (3,000MW each in the Eighth 5-Year Plan and Ninth 5-Year Plan). In terms of the scale of construction, during the Eighth 5-Year Plan the scale of large and medium-sized conventional hydropower is 32,130MW (13,280MW carried over from the Seventh 5-Year Plan, new construction starts on 18,850MW), and an effort to add an additional 1,600MW) and pumped-storage power stations would be 6,030MW (2,230MW carried over from the Seventh 5-Year Plan). During the Ninth 5-Year Plan, there will be 44,260MW in large and medium-sized conventional hydropower (22,340MW carried over from the Eighth 5-Year Plan) and 5,860MW in pumped-storage power stations (4,260MW carried over from the Eighth 5-Year Plan). This could add up to a total hydropower installed generating capacity of 80,000MW (at full bore) at the end of this century, which would be 18 percent of our developable capacity, and the hydropower installed generating capacity would account for 30 percent of the total installed generating capacity in China and 20 percent of our power output, which would restore it to the 1986 proportions. These are our overall goals and general arrangements, and there of course may be some readjustments in the actual figures and projects. It is apparent that the hydropower capacity we must build over the next decade will exceed the total for the past 40 years and the amount of hydropower that must be placed into operation each year will be more than 3 times the current level, so we are facing extremely arduous tasks.

### II. Hydropower Construction Programs and Deployments

In hydropower construction over the next 10 years, our main focus will be on construction of large and medium-sized conventional hydropower stations on primary river sections. The secondary focus will be on construction of conventional hydropower in other regions, local medium and small-scale hydropower, and pumped-storage power stations. I will list the most important projects below.

1. Conventional hydropower on key river segments: 1) Trunk of the Chang Jiang: Three Gorges hydropower stations will supply central China, east China, and east Sichuan, but they will not begin operation until the next century; Xiangjiaba on the Jinsha Jiang is a more realistic point and work should be speeded up to build it as soon as possible. 2) Upper reaches of the Huang He: Lijia Gorge and Daxia Gorge now under construction may go into full operation during the Ninth 5-Year Plan; we plan to start construction of Gongba Gorge and Xiaoxia Gorge during the Eighth 5-Year Plan and Laxiwa and Heishan Gorge during the Ninth 5-Year Plan. This could more or less complete development of the river segment in the upper reaches of the Huang He. 3) Middle reaches of the Huang He: construction will begin at Wanjiashai



and Xiaolangdi during the Eighth 5-Year Plan and at Longkou and others during the Ninth 5-Year Plan. Development of this river segment must be closely integrated with water conservancy systems. 4) Hongshui He: Tianshengqiao second cascade and Yantan are now under construction and they may go into operation during the middle part of the Eighth 5-Year Plan; during the Eighth 5-Year Plan, we will begin construction of the Tianshengqiao first cascade, expansion of the Tianshengqiao second cascade, and construction of a key project, Longtan; construction of Dateng Gorge and other projects will begin during the Ninth 5-Year Plan. This will basically complete development of the hydropower "motherlode" on the Hongshui He. 5) Lancang Jiang: Manwan, now under construction, will go into operation during the Eighth 5-Year Plan, and we will begin construction at Dazhaoshan during the Eighth 5-Year Plan and Xiaowan during the Ninth 5-Year Plan, achieving the transmission of power from Yunnan to east China. 6) Wu Jiang: Dongfeng, now under construction, will go into operation during the Eighth 5-Year Plan, and we will begin construction of Hongjiadu during the Eighth 5-Year Plan and Silin, Pengshui, and Goupitan during the Ninth 5-Year Plan, basically completing development of the Wu Jiang. 7) Dadu He and Yalong Jiang: Ertan, now under construction, will begin operating in the Ninth 5-Year Plan; over the next decade we must also start construction at Tongzilin and Baobugou or the Jinping second cascade. 8) Tributaries of the middle reaches of the Chang Jiang: Wuqiangxi and Geheyan, now under construction, will begin operation during the Eighth 5-Year Plan; we plan to begin construction of Gaobazhou, Shuibuya, Pankou, Jiangya, and Han Jiang cascade (integrated power and water-borne shipping) during the Eighth 5-Year Plan; we will begin construction of Wanmipo and others during the Ninth 5-Year Plan.

2. Other regions: 1) East China region: Shuikou, now under construction, will begin operation in the Eighth 5-Year Plan; we plan to start building Muyangxi and Mianhuatan during the Eighth 5-Year Plan; we will begin construction of Jieman and Tankeng during the Ninth 5-Year Plan. 2) Northeast China region: the second phase at Baishan is now under construction, and we will begin construction of Gaoling Jinkeng, the Songjiang He cascades, Lianhua, and so on during the Eighth 5-Year Plan. 3) Tibet and Xinjiang: Yanghu pumped-storage and Dashankou are now under construction, and we plan in the future to begin construction of Kaxgar second cascade, Shikong, Jilintai, and others.

3. Medium-sized hydropower, divided into two categories: 1) Rather large capacity (over 100MW): Hongjiang, Lingjintan, Nanyahe cascade, Dongxiguan, and others will be connected to grids and included in grid power equilibrium plans; 2) Hydropower developed mainly by local areas: the overall plan for development over 10 years is 6,000MW, with 2,000MW going into operation during the Eighth 5-Year Plan and 3,000MW going into operation during the Ninth 5-Year Plan. China's

medium-sized hydropower resources have been basically investigated and we have prepared a rather complete list, but substantial efforts will be required to actually implement this development plan.

4. Pumped-storage: Guangzhou and Shisanling pumped-storage power stations are now under construction and we will begin construction of Tianhuangping and Liaoning pumped-storage power stations during the Eighth 5-Year Plan; we will also build Zhanghewan, Xilongchi, Guangzhou second phase, and other pumped-storage power stations during the Ninth 5-Year Plan.

The projects listed above are all major points and there is relative agreement among departments and local areas in regard to the development, planning, program design, investments, and so on for these points.

### III. Attacks on Key S&T Problems During the Eighth 5-Year Plan

There must be major developments in science and technology and substantial improvements in management if we wish to complete the tasks listed above. The state has decided that it will carry out management and supervise implementation of future attacks on key S&T problems by levels. Although a final draft has not been prepared for state attacks on key S&T problems during the Eighth 5-Year Plan, the following projects are expected to be chosen in the area of hydropower development:

1. Sets of technologies for construction of 200 to 300 meter high dams. Dam heights for many key hydropower stations in the future will have to exceed 200 meters and some will even attain the 300 meter grade. We must grasp sets of technologies for construction of this type of dam, including concrete dams and earth and rockfill dams. China's earth and rockfill dam technologies are even more backward, but this type of dam will be the target of focus for future development.

2. High rolled concrete gravity dams and rolled concrete arch dams. Gratifying achievements were made in the area of rolled concrete dams in China during the Seventh 5-Year Plan and we are now preparing to extend this technology for 150 meter-grade gravity dams and 100 meter-grade arch dams. This will create a new situation in concrete dam design and construction.

3. Key technologies for high head and large capacity pumped-storage power stations. These mainly refer to design and manufacturing of generator equipment and include prospecting, design, operation, and other technologies. We should attack key problems to base ourselves on domestic sources and use our own technology and equipment to build high head, large capacity pumped-storage power stations.

4. Hydropower equipment for the Three Gorges and other large projects. Hydropower equipment for this project includes water turbine generators, electromechanical equipment, metallic structures, and so on, as well as special-purpose construction equipment for

hydropower. The main focus of our attacks on key problems will be water turbine generators, ship passage facilities for high dams, and large special-purpose construction equipment.

5. Sets of 500 kV power transmission and transformation equipment. These are used for hydropower as well as thermal power. However, because China's hydropower resources are concentrated in southwest and northwest China, we must truly make major development efforts and achieve the transmission of power from west China to east China, so there is an extreme need to grasp ultra-high voltage power transmission and transformation technology.

In state-level projects to attack key S&T problems, we also should focus on attacking key S&T problems in our industry. Projects to attack key S&T problems in the industry for 1990 and 1991 have already been assigned and there are many of them, including new hydraulic materials, earthquake resistance, energy dissipation, high slopes, large dam safety monitoring, hydropower station computer monitoring and control, and so on. In the area of equipment development, they include high-speed cable machines, automatic mixing buildings, crawling tanks, and through flow generators. In the area of planning, they include hydropower station capacity increases, design floodwater analysis, computer software development, expert systems development, and so on. We should coordinate with the requirements in state attacks on key S&T problems and coordinate with hydropower construction tasks over the next decade, make more arrangements for concrete tasks and projects after 1992, and work on consideration of plans for the next 5 years to attack key S&T problems in the industry. Some projects, like large-scale blasting for dam construction, tidal power station development, and so on require further research to determine how to proceed.

#### IV. Problems and Difficulties that Exist

In view of the need to make full use of hydropower resources, alleviate the pressures on coal production and transportation, reduce environmental pollution, and optimize the energy resource structure, the hydropower construction plan outlined above is actually only a rather low objective and many comrades may feel dissatisfied. Still, there are many problems and difficulties involved in achieving this sort of plan and if we fail to give them consideration, do not make appeals, and the state does not adopt effective measures, this plan cannot be implemented. Concretely speaking, this involves the following points:

1. The above plan is only the tentative ideas of comrades in the Ministry of Energy Resources who are involved in planning and preparatory work. Although it has been discussed repeatedly, been turned into written form many times, and been submitted to high authorities on several occasions, it has not received formal approval from the state, so it is still not a directive-type plan. We feel that compilation of a national energy resource plan

is serious work and that the state should organize its completion and formally approve measures to turn it into a document with legal binding force. If the plan is not completed and the pace of the four modernizations drive is damaged as a result, the relevant departments should assume legal responsibility. Establishment of hydropower projects now is extremely difficult. Usually, they must be suggested by basic levels and beseech the state for agreement, and even then they are often rejected because of a "failure to implement capital raising". Thus, the end result is that hydropower plans cannot be completed, so who should be held responsible? We feel that the current upside-down method of doing things in which "planning commissions manage micro examination and acceptance while grassroots levels do macro planning" cannot be allowed to continue.

2. Failure to implement capital. We must solve the problem of capital channels if we want to build this many hydropower stations. Implementing a method of investment diversification and making provinces the main forces for electric power would play a great role in motivating the initiative of local areas for developing power and there would be very rapid development of thermal power construction. It must also be noted, however, that there would be an abrupt reduction in the proportion of large-scale hydropower, which depends mainly on state investments. Investments in hydropower construction have undergone a linear decline from 35 percent of total investments in electric power in China during the Fourth 5-Year Plan to 18 percent in the Seventh 5-Year Plan, and the figure for 1990 was just 16.7 percent. Local areas, banks, and investment departments also are unwilling to or find it difficult to invest in hydropower, sometimes to the extent that projects under construction cannot arrange rational construction schedules and new projects are unable to begin construction, which makes reserve strengths for hydropower very weak. If we fail to begin construction of several new large hydropower stations during the first 2 years of the Eighth 5-Year Plan, no hydropower capacity will be placed into operation after 1997. Now, we have proposed that 29 projects be started during the Eighth 5-Year Plan, but project proposals have been submitted to higher authorities for only five projects and no capital has been implemented for the remaining ones. If this situation is not changed, talk of developing hydropower and completing plan tasks will be meaningless.

3. Failure to implement preparatory work. Considering the need to place 45,000MW into operation before the year 2000 and calculating based on a ratio of 4:2:1 for feasibility research, preliminary designs, and projects under construction, a great deal of work must be done on feasibility research and preliminary designs in preparation. However, there was just 15,000MW in preliminary design reserves at the end of 1989 and just 24,120MW in feasibility research (not including the Three Gorges project), so the discrepancy is too large. According to arrangements made by the Central Water Conservancy and Hydropower Planning and Design Academy, about

200 million yuan must be spent each year on preparatory work in the area of hydropower, but less than 100 million yuan is now being spent. The result is that preparatory work for many projects cannot be done intensively, many technical programs cannot be resolved, and scientific research and experiment work cannot be carried out. If this problem is not solved, meaning that the state arranges for construction capital, we will be unable to accelerate hydropower construction or we will again take the old path of "doing all three things simultaneously", which will have a negative outcome.

4. The problem of coordinating relationships and handling contradictions has not been resolved. Many hydropower projects have rather large comprehensive benefits, but they also generate divergent views and contradictions among the various departments involved in comprehensive utilization. It should be acknowledged that because we did not handle problems in this area very well in the past, the abnormal situation of "the greater the comprehensive benefits, the more difficult the project construction" appeared. There are now quite a few important projects in plans where contradictions in this area have appeared. If they are not resolved well, construction will be impossible. For example, several large hydropower stations are located on rivers which form provincial or autonomous region borders, or the power plants and large dams are downstream while the reservoirs are upstream in another province. This leads to different views among provinces and autonomous regions concerning hydropower resource development patterns and allocation of benefits and unanimity of views sometimes cannot be achieved. This also affects timely and rational development of hydropower resources. The power generated by several large hydropower stations must be transmitted to distant provinces and autonomous regions, so development requires coordination with the relevant provinces and autonomous regions to unify views, raise capital, and discuss the various methods to be used. Recently, four provinces in south China reached agreement on unified development of power, and this is an excellent starting point. We hope that it can be adhered to in the future and that even more provinces and autonomous regions will cooperate to develop power.

#### V. Tentative Ideas on Measures To Resolve Problems

1. I propose that the state authorize departments to organize the Ministry of Energy Resources to meet with the relevant departments, provinces, and autonomous regions according to the national distribution of energy resources and economic development plans for each region for formal formulation of a medium and long-term national energy resource (electric power) development and construction plan and for concrete plans for the next 5 and 10 years that organically include hydropower development plans and make them a part of comprehensive development of China's energy resources. This energy resource (hydropower) development plan should be comprehensive, optimized, and implemented. After this plan is approved by the State

Council, it should be one of the state's basic development plans and should have binding force and all departments should be responsible for completing this basic plan. Use this plan as a foundation for formulating the corresponding special plans for capital raising, materials supply, population resettlement, environmental protection, scientific research, preparatory work, and other areas and implement each of them. The state can use this basic plan as a foundation for formulating the related policies, measures, laws, and regulations to ensure that the plan is achieved.

2. Make proper arrangements for solving the problem of capital sources for hydropower construction. All industries and sectors in China are now deeply feeling the difficulties of the capital shortage. Hydropower construction is capital-intensive and the longer the investment schedule the more acute the problem, so we must achieve proper solutions that are only possible when there are several clear channels. Our ideas are: 1) Huge, large, multi-province or multi-autonomous region, and multi-river basin hydropower construction, especially projects of strategic power, still require state support, so we propose that the number of projects for which central authorities arrange for hydropower investments should be increased. Comrades in the central government are now considering several major projects that will be built with a suitable degree of centralized capital, and we urgently hope that river basin development and hydropower construction will be included among major matters handled by central authorities. 2) We hope that farsighted local leaders can increase investments in hydropower. Sichuan Province has decided to invest in development of Ertan, Hubei Province has decided to invest in development of Geheyan, Yunnan Province has decided to invest in development of Manwan, and so on. All of these are good models. We admire the foresight and sagacity of these provincial leaders in laying a solid foundation for industrial and agricultural development in their provinces. We hope to see local areas invest more capital in hydropower in the future and we hope that central authorities will formulate several necessary stipulations and measures (for example, stipulating that the electric power construction fund requisitioned from the amount of power generated by hydropower be returned to hydropower construction) for guidance. 3) We should create a variety of channels to raise capital for hydropower and welcome provinces and municipalities with greater economic strength in investing in other provinces to develop hydropower, and this includes rational utilization of foreign capital. In most situations, although electric power cannot directly earn foreign exchange, if it is developed in conjunction with minerals and so on, it may also use mineral products as a carrier to earn foreign exchange or reduce exports from foreign countries, which can create the conditions for repaying foreign investments. We hope that state planning and economics and trade departments will provide support and cooperation.

3. We should formulate policies biased toward hydropower and measures to solve contradictions. We

feel that: 1) Hydropower involves simultaneous development of both primary and secondary energy resources and hydropower should be given the same preferential treatment as coal, petroleum, and other primary energy resource development, especially in the area of loans. We have been calling for this for quite some time and we hope that it can be stated clearly in policies. 2) Hydropower development often includes huge simultaneous comprehensive benefits like flood prevention, irrigation, and so on, so it should be exempted from cultivated land utilization taxes like other water conservancy projects. However, enormous cultivated land utilization taxes are currently being requisitioned from hydropower. Besides the 30 percent that is returned to the state treasury, most of it is turned over to local finances for use on other purposes. This greatly increases the burden on hydropower investments and is extremely irrational from an overall perspective. We have argued strongly about this many times in the past but we have still not gained the understanding of higher authorities and the relevant departments. We hope that everyone will continue to issue this call together. 3) Hydropower stations with huge comprehensive utilization benefits should begin with the overall national interest and formulate planning and design principles and rational and feasible investment sharing methods to avoid each department making demands solely from their own perspectives and creating contradictions and disputes. Rational benefit allocation principles also should be formulated for the development of border rivers or rivers which pass through more than one province to provide comprehensive utilization projects and multi-province projects with regulations they can follow, immediately resolve contradictions, unify understandings, and carry out construction as quickly as possible. 4) We should formulate a reservoir population resettlement law that takes into account the interests of the state, local areas, and the people, tie reservoir region development to power station benefits, and thereby enable the use of rather limited capital construction investments to solve the problem of arrangements for resettled people. This will enable the resettled populations to live and work in peace and contentment and enable more rapid economic development in reservoir regions, and it will provide benefits not only to areas downstream from reservoirs but also bring prosperity to the reservoir region. 5) Preferential and flexible policies should be provided to hydropower development companies to give them greater vitality and enable them to raise more capital and more quickly promote rolling development of hydropower construction. In summary, the state's formulation of several rational and feasible policies and measures for the hydropower industry could promote the development of hydropower as well as truly foster the advantages of hydropower, fully embody the economic and social benefits of hydropower, enable hydropower to enter the "market" on just foundation, engage in competition, and attract investments.

4. Go all out in attacking key S&T problems, raise hydropower development technologies to new levels.

The future tasks to develop hydropower are extremely arduous, natural conditions are becoming increasingly complex, communication is becoming more inconvenient, project scales continue to grow, and restricting factors in all areas are becoming more burdensome, so finding ways to reduce construction costs and accelerate project progress are obviously much more important. We must rely on S&T progress and step up to a new stage if we wish to truly resolve problems, truly reveal hydropower's advantages, and truly attract all areas to develop hydropower. We must liberate our ideas, take somewhat larger steps, and move more quickly. This is truly a heavy burden but we must be determined to make breakthroughs. If we stick to conventions and always trail behind foreigners, we will find it hard to complete the tasks that the era has set before us. China's overall S&T levels are backward compared to advanced world levels, but we can catch up in many industries. Looking at the level of our hydropower development, we certainly have the conditions to take the lead and catch up to advanced world levels and use this to encourage the morale and fighting will in all industries in China.

## VI. Conclusion

The tasks we face are extremely glorious and the difficulties are extremely great. Our hydropower resources are the valuable wealth of the motherland and a treasure given to us by nature. We have the responsibility and duty to develop them, serve the socialist four modernizations drive, and create prosperity for our descendants. Although we face many difficulties and obstacles, we cannot waver or relax our efforts. The hydropower industry is certainly in rather difficult straits now. It faces a capital shortage, insufficient construction starts, serious idleness, a lack of successors, several misunderstandings in all areas of society, and so on. All these are temporary, however, and I am confident that during the process of intensive reform and implementation of opening up, under the correct leadership of central authorities, and through our efforts, these difficulties will eventually be overcome and resolved. Leaders in the central government are now extremely concerned with hydropower and it can be said with certainty that China's hydropower industry has brilliant and glorious prospects. It will certainly see greater development and will there will certainly be even more people from the younger generation who dedicate themselves to this magnificent and glorious undertaking. Allow us to unite in struggle, move forward with bravery, and welcome major development of China's hydropower industry!

(This article is a summary of a speech given by the author at the 3d Conference of Delegates to the China Hydroelectric Power Engineering Society on 23 Oct 90. It was abridged slightly for publication in SHUILI FADIAN and his opinions were solicited).



### Accelerating Hydropower Construction in East China

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[Article by Zhang Fahua [1728 4099 5478] of the East China Survey and Design Academy: "Intensively Develop Hydropower Resources, Accelerate Hydropower Construction in East China"]

[Text] Major accomplishments have been made in construction in the electric power industry in the five provinces and one municipality of the east China region, Shanghai, Jiangsu, Anhui, Zhejiang, Fujian, and Jiangxi. The region's total installed generating capacity has increased from 386MW in 1949 to 26,000MW at the end of 1988 and yearly power output has grown from 1.29 billion kWh to 119 billion kWh. It had no hydropower before liberation but now they have developed 7,200MW in hydropower resources, about 40 percent of the developable amount in the region. This includes 28 large and medium-sized hydropower stations which have been completed and placed into operation with a total installed generating capacity of 3,160MW and yearly power output of 10 billion kWh.

To achieve the "three step" deployment and the goals of the second step in China's economic development strategy, the scale of electric power construction in China over the next decade will be roughly the same as the total amount since the nation was founded 41 years ago. This includes over 50,000MW in increased total installed generating capacity for hydropower, so the tasks are even more glorious and arduous. The three provinces and one municipality in the East China Grid, Jiangsu, Zhejiang, Anhui, and Shanghai, account for over one-fourth of China's GNP. Fujian was restricted by historical conditions in the past and could not go all out in construction. Since the CPC Central Committee proposed the peaceful unification of the motherland and the policy of reform and opening up, the pace of construction has accelerated. Construction in the old soviet region of Jiangxi is also advancing rapidly. As a result, the pace of development and demand for electric power in the east China region in the next decade may surpass the national average level. Forecasts indicate that by the year 2000, the peak load in the East China Grid alone will be 35,800 to 41,500MW and the grid's total installed generating capacity will reach 45,850 to 51,700MW.

Thermal power is the dominant force in the East China Grid, but the east China region has a shortage of energy resources and very few coal resources. It has been predicted that by the year 2000, thermal power production in the East China Grid alone will require shipping 120 million tons of raw coal in from other regions. Extraction and shipping will require the investment of enormous amounts of capital, take a very long time, and be extremely difficult. It is now extremely hard to maintain the coal used to generate power in existing thermal power equipment. Beginning in 1988, forced

shutdowns of generators due to an historically unprecedented shortage of coal appeared and in Jiangsu Province alone it was so serious at one time that 1,050MW of generators were shut down. The extent of the problem in coal supplies in the east China region over the next decade may exceed our present predictions, and this would severely restrict future development of electric power. Large-scale construction of nuclear power awaits batch production of the equipment after a shift to domestic sources and maturation, so the total nuclear power installed generating capacity in the grid prior to 2000 may be only 1,500MW. There are still 9,660MW of developable hydropower resources in the east China region at present which could generate 38.5 billion kWh of power a year. Although these resources are not large and their economic indices are poorer than the "motherlode" in northwest and southwest China, they are still a valuable and clean renewable energy resource that the region could develop locally. In the area of investments, the overall investments would not be greater than those for thermal power and the associated coal extraction and transportation. Thus, we should borrow from the experiences of the extremely high degree of development of hydropower resources in the economically developed nations of Europe and make the painful decision to accelerate development and utilization of hydropower resources to alleviate difficulties in coal supplies. Moreover, the region has about 20,000MW of coastal tidal energy resources, about 92 percent of the total in China, that could generate about 51 billion kWh of power annually, and they are actively studying the question of developing and utilizing them.

Based on the energy resource shortage in the east China region and the characteristics of the East China Grid, accelerating hydropower construction means that we should carry out intensive development of hydropower resources, meaning construction of pumped-storage power stations and expansion of capacity at existing hydropower stations, pushing forward with construction of several medium-sized hydropower stations, and actively making preparations to build large key hydropower stations. We also must focus on research and further experimentation concerning development and utilization of tidal energy. This could satisfy the need for power equilibrium in the electric power system, reduce the contradiction of a serious shortage of peak regulation and accident reserve capacity, conserve more power source construction investments, and reduce the problem of coal shortages.

#### I. On Construction of Pumped-Storage Power Stations

Thermal power is the dominant force in the East China Grid. The hydropower installed generating capacity has fallen from 30 percent during the 1960's to 12.0 percent now. There is just 1,700MW of hydropower installed generating capacity with a peak regulation capability. No hydropower generators will be placed into operation during the Eighth 5-Year Plan, so the proportion is expected to drop to 8 percent by 1995. However, the maximum peak-to-valley differential in daily loads has

now reached 3,560MW and the grid is operating under conditions of no reserve capacity and inadequate peak regulation measures. Actually, users are forced to serve as reserve and peak regulation measures. Over the past 5 years, excluding the fall and winter of 1989, the daily load rate was always above 90 percent or so and reached a maximum of 93 percent. Many thermal power generators are in operation for 7,500 hours a year. This is inadequate for the operation of plants and enterprises, power cycles are unstable, and there are frequent power restrictions. Low cycles are appearing not just during peak periods. Beginning in 1988, low valley high cycles began appearing that were hard to counteract. Overall, the East China Grid has a power shortage and an even greater capacity shortage. This situation actually is already hard to continue. As the economy develops and we open up to the outside world and as S&T advance and the people's living standards rise, increasingly higher demands will be placed on the quality of power supplies and losses from sudden power outages will grow larger. Using township and town enterprises as an example, since implementation of the policy of reform and opening up, the rise of township and town enterprises in a situation of power shortages has meant that many employees in these enterprises produce whenever power is available, remaining in their workshops day and night or on holidays to start producing as soon as power is supplied. Rural living standards have risen over the past several years and major changes have occurred in conditions. In early 1988, for example, although there were sufficient supplies of power to rural areas in Jiangsu on the eve of the New Year, nearly all their township and town enterprises had shut down and their employees had gone home to enjoy New Year's eve to say goodbye to the old year and welcome the new one. At 4 P.M. the power load dropped to its lowest point, but at 6:30 P.M., just 2.5 hours later, the power load surged by 1,400MW. This shows that the long-term situation of forcing users to serve as reserve and peak regulation measures cannot continue. The trend toward increasingly higher demands being placed on the quality of power supplies cannot be turned around by the will of man. The quality of power supplies not only affects production and life. In reality, it also affects social stability. It is urgent that the problem of peak regulation be resolved.

According to projections in electric power plans, the peak-to-valley differential in the daily loads of the East China Grid will reach 11,400 to 12,300MW by the year 2000. At that time, only 2,540MW of conventional hydropower will be capable of serving as peak regulation capacity, even taking into account Tankeng and Shanxi hydropower stations after they are built and go into operation, so there will still be a large shortage of peak regulation capacity. In a situation of shortages of construction capital, building high-head pumped-storage power stations is the best countermeasure for taking on peak regulation tasks. According to information in existing plans, there are 18 sites where large and medium-sized pumped-storage power stations could be built in Zhejiang Province alone with a capacity of more

than 20,000MW. The reasons for building pumped-storage power stations are that: 1) they are capable of peak regulation and can fill in valleys, with 1 kW in peak regulation (valley filling) capabilities at a pumped-storage power station equalling 2 kW at a conventional hydropower station; 2) from the perspective of an entire system, because the operating conditions of many thermal power generators are improved after construction of a pumped-storage power station, total coal consumption in an electric power system can be reduced; 3) at pumped-storage power stations with superior conditions, the investment per kW is lower than for thermal power, which can conserve power source construction investments. At Tianhuangping pumped-storage power station, where the feasibility research report passed examination back in 1986, the natural head from above to below the reservoir is as much as 600 meters. It would have an installed generating capacity of 1,800MW, with good development conditions. No people would have to be resettled and only 15 mu of cultivated land would have to be inundated. The investment would be 1,000 yuan/kW, which is much cheaper than thermal power. After its completion, the peak regulation could solve the problem of low cycles and fill in valleys to solve the problem of low cycles. It also could assume 3,600MW in system peak-to-valley differential, change the output of 12,000MW of high-temperature high-pressure thermal power generators and shift them from high coal consumption to stable output, high efficiency, low coal consumption operation, conserve total coal consumption in the electric power system, and operate for 3 hours to replace 600MW in accident reserve capacity or 6 hours to replace 300MW, so the benefits are outstanding. Besides Tianhuangping, a large key pumped-storage power station, we also are searching for several medium-sized and small pumped-storage power stations with very good conditions in areas near concentrated loads to create excellent conditions for local areas to build several medium-sized and small pumped-storage power stations with superior conditions. Many local governments are very enthusiastic about building this type of power station. In Fujian Province, which has a large proportion of hydropower and much seasonal power, we should search for plant sites for pumped-storage power stations with seasonal or perennial regulation properties and study their economic development.

## II. On Expansion of Existing Hydropower Stations

The total installed generating capacity in the East China Grid continues to grow and will surpass 45,800MW in the year 2000. High-temperature high-pressure generators with a single unit capacity of 600MW will also enter the system, so increasingly higher demands will be placed on electric power system reserve capacity. If we calculate at 6 percent of the maximum load in the system, 2,150MW will be required for hot reserve capacity. Because hydropower stations can be started up flexibly and quickly, they are best suited to assuming accident reserve and rotating reserve tasks. This is a generally acknowledged fact. In the East China Grid, the

existing hydropower stations that can be expanded to increase capacity include Xin'anjiang, Hunanzhen, and Huangyunkou in Zhejiang, and other hydropower stations. The total expansion of capacity would be about 1,000MW. Ansha hydropower station in Fujian and Zhelin in Jiangxi also can be expanded. These projects already have reservoirs, so there is no problem of inundating cultivated land or population resettlement. The investment per kW would usually be lower than adding new thermal power generators. Their main task would be to assume system reserve and peak regulation tasks, especially rotating reserves, to reduce the hot reserve capacity of thermal power generators, and increase electric power system operational stability and utilization rates of thermal power equipment.

However, there is still no unified understanding of the question of expanding existing hydropower stations in the East China Grid and policies have not been implemented. Back in the summer of 1984, minister Qian Zhengying [6929 2973 5391] of the former Ministry of Water Resources and Electric Power set out the issue of expanding Xin'anjiang hydropower station and he made several personal visits to it afterwards. We have also done a great deal of research work in a situation of shortages of preparatory work funds and proposed preliminary feasibility research reports. Because of limited increases in power output following expansion of existing hydropower stations, however, the value of the capacity was not fully reflected. This provided limited capability of repaying the investment for expansion and this matter was never pursued fully. Actually, the benefits of expansion and the question of investment repayment abilities should be given unified consideration from the perspective of an entire electric power system. If one says, for example, that there should be no expansion of a 1,000MW hydropower station, objectively speaking an electric power system would still require this capacity and would have to make thermal power generators or other power sources responsible for it. Solely from the need to deal with accident emergencies, if we consider the need for the input of reserve capacity within 2 minutes after an accident occurs, this presents no problem for hydropower stations. However, calculating at a 3 percent increase in load per minute for thermal power generators, this would require 56 single generators with a capacity of 300MW to remain in hot reserve state operation year-round. This 1,000MW of thermal power generators would also cost money, actually a larger investment than that for expansion of a hydropower station, and more coal would be consumed during hot reserve operation.

As for the problem of an ability to repay the investment for expansion, our socialist country, which respects objective laws and advocates maintaining overall interests, should be able to solve it. During a meeting of leaders in the East China Grid 3 years ago, Shanghai Municipality deputy mayor Huang Ju [7806 5468] said he hoped that power plants under the direct jurisdiction of the grid bureau would assume responsibility for more

peak regulation and reserve tasks to enable stable operation of local thermal power. Everyone would compensate power plants for their losses in assuming responsibility for peak regulation and accident reserve tasks. I feel that, based on this spirit, coordination should be carried out within the power grid and that the corresponding rational and feasible policies and accounting methods should be formulated.

### III. On Construction of Conventional Hydropower Stations

The east China region still has 9,660MW of developable hydropower resources that could produce 38.5 billion kWh. The large and medium-sized key power stations that should be built in succession in the late Eighth 5-Year Plan and early Ninth 5-Year Plan are: Tankeng (600MW) and Shanxi (240MW) in Zhejiang, Taihe (180MW) in Jiangxi, and Mianhuatan (600MW) in Fujian, for a total capacity of 1,620MW. Another 4,760MW in medium-scale hydropower also can be developed in Zhejiang, Fujian, and Jiangxi that could produce 19.6 billion kWh. There are some among them with very good development conditions where we could carry out cascade development or cascade rolling development, such as Sha Xi (6 levels for 230MW) in Fujian, Xiu He (six levels for 260MW) and Suichuan Jiang (two levels for 63.5MW) in Jiangxi, and Fenshui Jiang (eight levels for 120MW) in Zhejiang. For developable conventional hydropower, Fujian Province has roughly double the resources of Zhejiang Province and the degree of development is lower there. Hydropower accounts for a rather large proportion in the grid and there is much seasonal power. In the long-term view, it would be appropriate to connect the Fujian and East China grids. This could make full use of the four large perennial regulation reservoirs (with a total effective reservoir capacity of 14.8 billion cubic meters) already built at Xin'anjiang and Hunanzhen and planned for construction at Tankeng and Shanxi in Zhejiang to carry out compensated regulation and enable reallocation of this hard-to-digest seasonal power according to real needs in the electric power system. This is a good thing that would benefit development of Fujian's hydropower resources. Moreover, after interconnection of these two grids with different load characteristics, there would be benefits from grid interconnection itself. This point was fully demonstrated in the evaluation of the Shuikou project.

As for accelerating hydropower construction, the Ministry of Energy Resources already has rather systematic and clear policies. To push forward with construction of several medium-sized hydropower stations, the Ministry of Energy Resources and the Investment Company held a special conference on medium-sized hydropower in some of the provinces (autonomous regions) of south China in November 1989 which had very clear guiding ideologies, principles, and policies. If these projects could be implemented in succession, they would effectively promote hydropower construction throughout China. I will now discuss some viewpoints in regard to the situation in the east China region alone:

1. There should be preferential policies for raising capital to develop hydropower, or at least equally fair conditions compared to those for raising capital to develop thermal power. There is much enthusiasm for developing power in the east China region, especially in the three provinces and one municipality in the East China Grid. Reform of the electric power system got underway rather early and there have been major steps. They began raising capital to develop power 6 years ago, but they have still not raised capital to develop a single conventional hydropower station. This deserves deep thought. Looking at the reasons, one important one is that to develop thermal power, they only have to raise capital to develop a thermal power plant, which is a secondary energy resource. They do not have to raise capital for capital construction of the coal mines and coal transportation to supply coal to the thermal power plants. Development of hydropower involves simultaneous development of primary and secondary energy resources, so the investment of course would be much larger than for a thermal power plant itself. Added to irrational electricity prices, state subsidies for the price of coal used for thermal power, and the fact that the required estimation of the dynamic benefits of hydropower in the system has still not been made, although the results of economic analyses of hydropower stations are very good, they are much poorer in terms of financial analysis. In this situation, those raising capital must spend 2 yuan to develop hydropower for every 1 yuan they would have to use to develop thermal power, so who would be enthusiastic about developing hydropower? As an economic entity, when selecting power sources for development, their behavior is often affected by returns to investments. The state, however, cannot avoid investments in coal mines and transportation.

2. Reservoir region inundation and population resettlement is a big problem for the east China region in developing conventional hydropower. This should be treated as a major question in hydropower development plans and research should be done simultaneously. Historical experience has proven that now we should take the path of developmental resettlement. In this area, the Xin'anjiang reservoir region took full advantage of the microclimate formed by the reservoir to carry out comprehensive development and their experience in beach reclamation along the coast to resettle the population deserves summarization and extension.

Xin'anjiang hydropower station fully utilized and fostered the effects of resource conversion and the favorable natural ecological environment after the reservoir was formed and made gratifying achievements by taking the route of developmental resettlement, which mainly includes these two areas. One, they made use of the two large agricultural climates in the lake region and mountain region to develop agricultural production and develop mountain and water resources in a "high mountains, hills, lake surface, in-water" four-level cascade arrangement to form three-dimensional agriculture and fully exploit the environmental capacity. Two, they

relaxed policies, developed the economy, readjusted the industrial structure according to market demand, and focused support on development of township and town enterprises. By adopting these measures, they made local arrangements using developmental production for the 20,000-plus people originally planned for resettlement outside of Chungan County. Beginning in 1987, the per capita incomes of the resettled population in the reservoir region had risen slightly above the average levels for the county as a whole.

The east China coast has over 10 million mu of beach resources, 4.33 million mu of which is in Zhejiang Province. Since the nation was founded, all of the counties along the Zhejiang coast have reclaimed nearly 2 million mu of beach area to develop cropping and breeding. Xiaoshan County in Zhejiang Province, for example, has reclaimed 410,000 mu of beach area over the past several years (including an area of 240,000 mu that was reclaimed and planted). They made arrangements for over 60,000 people, developed aquatic breeding, cropping, and other activities, and produced a total gross value of industrial and agricultural output of 1 billion yuan. Their per capita incomes are more than 40 percent higher than the peasant per capita incomes for the entire county, so the economic benefits are quite outstanding. From the perspective of investments, it usually costs about 3,000 yuan to enclose and reclaim fields, which is lower than the current level of expenditures on land requisition for reservoirs in Zhejiang Province (3,360 yuan/mu for Tankeng and 3,750 yuan/mu for Shanxi). Moreover, it usually takes 3 to 5 years from the start of construction to enclose and reclaim beaches, so it can be synchronized with construction of power stations.

3. I propose that in policies for pushing forward with construction of several medium-sized hydropower stations, preferential consideration and even more preferential policies should be provided for those projects which can implement cascade rolling development. For the Sha Xi cascade in Fujian, for example, the Ansha key reservoir lies above and six cascade levels lie below with a total installed generating capacity of 230MW. The three levels at Gaosha, Banzhuxi, and Shaxian would have a total installed generating capacity of 126MW at a total investment of 300 million yuan, and the Sanming region has an even stronger economy which can digest the electric power itself. If cascade rolling development can be carried out, using hydropower to develop hydropower, this would require only 40 percent of the total investment to completely finish these three cascade power stations within 8 years. If more preferential policies can be provided, this would entice local areas to raise capital and continue to carry out rolling development of medium-sized hydropower stations.

#### IV. On the Question of Actively Developing Tidal Energy

The coast of the east China region has 92 percent of China's total tidal energy resources with a developable



installed generating capacity of about 20,000MW that could generate about 57 billion kWh of power a year, which is equivalent to 30 million tons of raw coal a year. It has resources comparable to all of the developable hydropower resources on all of the rivers in the east China region, so it is an energy resource motherlode lying "at the front door" of the east China region. The development rate now is extremely low, however. With the growing energy shortage in the east China region, we must readjust the configuration of energy resources and implement diversified development, so tidal energy undoubtedly is one important part and route.

Because it utilizes low head, construction costs to develop tidal energy are rather high, but in a macro perspective development of tidal energy is economically rational. Construction of tidal power stations does not require the flooding of farmland but instead can create land for the development of aquatic breeding, improve communication, carry out extraction of uranium from seawater, and be done in integration with shipping channel improvement, harbor construction, and so on to obtain comprehensive economic and social benefits. Power stations also can work with hydropower stations in power grids to carry out electric power compensation and land compensation to make up for losses from reservoir inundation to build hydropower stations. Completion and generation of power at Jiangxia power station in Zhejiang Province will prove that China is capable of developing and utilizing tidal energy in the areas of project construction and generator manufacturing technology, and it will confirm that it is also economically sound. The actual investment for this power station is about 3,000 yuan/kW, so construction costs would appear to be rather high. However, besides the nearly 10 million kWh of power it will generate each year, it also can permit reclamation of 5,600 mu of land and 4,700 mu has been planted already in oranges, paddy rice, tubers, and other crops which have produced high yields every year. The net annual profit from prawn breeding each year for the reclaimed surface water area is 2 million yuan and the reservoir is being used for raising oysters, clams, mullet, and other aquatic products which produce net annual profits of more than 700,000 yuan. Unified planning for the water areas could generate even more enormous benefits. Another example is Leqing Bay tidal power station in Zhejiang which has a planned installed generating capacity of about 400MW. Besides generating 1.04 billion kWh of power annually, the steady winds and gentle waves in the reservoir prevent the loss of feed and organic matter, so they can make even greater use of their advantages as a base area for breeding razor clams, oysters, shellfish, fish, and other products. Moreover, about 110,000 mu of beach land can be enclosed and reclaimed. This is a major territorial development project that can compensate for the land flooded by three big Tankeng hydropower stations (600MW). After completion of the large dam at Leqing Bay, it can also serve as a huge bridge connecting the harbor at Damai Island to the mainland and the power station could also provide an important source of power

for harbor construction. Other tidal power stations like Xiamen, Beikou on the Chang Jiang, and so on could be integrated with shipping channel improvement, harbor construction, reclamation, breeding, and other things. Thus, development of tidal power stations can provide benefits from mountains and the sea and compensate for inadequate hydropower. The capital could be raised through a variety of channels.

At present, it will be hard to develop tidal power stations on a large scale due to limited state finances but the reality is that the east China region is facing a severe coal shortage. We have already obtained successful experience in building the Jiangxia MW-grade tidal power station and we should use this as a foundation for adapting to local conditions, working toward stable development and advancing steadily forward, and continuing to undertake survey research on resources and spend a small amount of finances and manpower to further clarify power station construction conditions. At the same time, we should focus on experiments to develop 10MW-grade power stations. There are Maluan Bay, Bachimen, Changyu, Jiantiao Harbor, Shizikou, Huangdun Harbor, and other station sites with extremely superior conditions along the east China coast. We should select 1 or 2 sites to focus on integrated experimental research on power station generator structure optimization, simplification, and substitute materials, marine structure floating structures and construction methods, comprehensive development and utilization benefits, capital raising policies, and other questions to gain additional experience and continue to develop toward construction of large and medium-sized tidal power stations. We should strive to do preparatory work for one or two 10MW-grade power stations during the Eighth 5-Year Plan, begin construction during the Ninth 5-Year Plan, and finish them before the year 2000. We also should undertake feasibility research and preparatory work for one or two large tidal power stations.

The east China region began developing hydropower rather early and built the Huangyunkou, Gutian Xi cascade, Shangyoujiang, and Chencun hydropower stations shortly after the nation was founded. In 1954, the region integrated with control of the Huai He and continued to build Foziling, Meishan, and Xianghongdian hydropower stations. In the fall of 1957, construction of Xin'anjiang hydropower station got underway and premier Zhou Enlai wrote an inscription himself: "Hail the victorious construction of the first large hydroelectric power station for which China did the designing and manufactured the equipment herself!", which provided substantial encouragement to China's huge hydropower construction army. The amount of time it took from the formal start of construction until the first generator began to produce power was just 1 year and 9 months at Xin'anjiang hydropower station and 2 years and 7 months at Shangyoujiang. These projects trained and created a brave hydropower construction staff that was skilled in battle and accumulated rich experience. Many old and young hydropower workers made outstanding contributions here. Looking toward the future,

the tasks are heavy and the road is long. I believe that if we just continue fostering the 1950's spirit of arduous struggle, unity and cooperation, and boldness in opening the way, and actively create the conditions, there is great hope for intensive development of hydropower in the east China region.

### Review of Hydropower Development on Upper Han Jiang

916B0054B Beijing SHULI FADIAN [WATER POWER] in Chinese No 2, 12 Feb 91, pp 16-19

[Article by Yang Zhilin [2799 0037 7792] and Zhao Dongchang [6392 2639 2490] of the Beijing Survey and Design Academy: "Review and Prospects of Hydropower Construction on the Trunk of the Upper Reaches of the Han Jiang"]

[Text] The Han Jiang is the longest tributary in the middle reaches of the Chang Jiang. Its source is in Ningqiang County in Shaanxi Province at the southern foot of Qinling. It runs for a total length of 1,567

percent of the total area of Shaanxi Province. The section between Yangxian County and the Jiahe is 430 kilometers long and has a head of 285 meters and developable hydropower resources of 3,619MW, of which 1,980MW is on the trunk and 1,639MW is on tributaries. It is a "motherlode" region of hydropower resources in Shaanxi Province. Since ancient times, the Han Jiang has been a "river to the sea" and important water-borne shipping channel through Shaanxi, Hubei, Henan, and Sichuan. Before a railroad was built along the river, it contributed to the exchange of material and cultural life of the people of southern Shaanxi. The 455 kilometer-long section of the upper Han Jiang within the borders of Shaanxi Province running from Yangxian County to Baihe can handle 10 to 50 ton vessels and it is open to traffic day and night within 175 kilometers of the Danjiangkou reservoir region. Figure 1 [not reproduced] is a map of the river basin and project locations in the upper reaches of the Han Jiang. Figure 2 shows a cross-section of the development of cascades on the trunk of the upper Han Jiang. I will now review and look at the prospects for hydropower construction on the trunk of the upper Han Jiang and offer some suggestions.

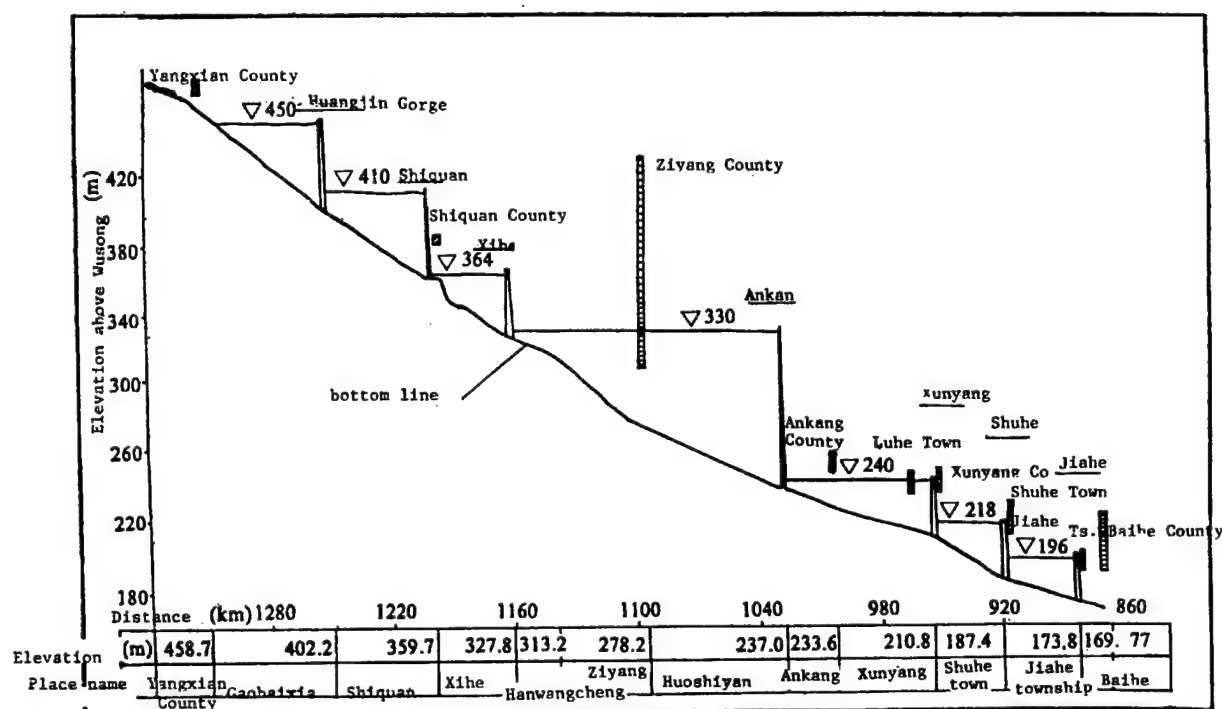


Figure 2. Cross-Section of Cascade Development on Trunk of the Upper Reaches of the Han Jiang

kilometers and has a basin covering an area of 159,000 square kilometers. The upper reaches segment above Danjiangkou [mouth of the Dan Jiang] is 918 kilometers long and has a basin covering 95,200 square kilometers. The upper reaches of the Han Jiang within the boundaries of Shaanxi Province runs from east to west over a length of 709 kilometers and has a river basin covering an area of nearly 60,000 square kilometers, equal to 29.2

### I. A Review of Hydropower Construction on the Trunk of the Upper Reaches of the Han Jiang

Before liberation, there was only the small Wujiagou hydropower station with an installed generating capacity of 200 kW at Hanzhong on the Baohui canal in the river basin in the upper reaches of the Han Jiang. Although water-borne shipping developed rather early, the fact

that the shipping channel was in a natural state limited its carrying capacity. After the establishment of New China, there were major developments in the hydropower and water-borne shipping industries on the upper Han Jiang. In the 1950's, the relevant units undertook planning work for the Han Jiang basin and described development and control of the Han Jiang and the question of comprehensive utilization of its water resources in the "Planning Report for the Han Jiang Basin" compiled in 1958 and proposed some development tasks. First, there was the need to prevent the danger of flooding in the plains region in the middle and lower reaches of the Han Jiang. Second came the development of irrigation and hydropower resources, improvement of water-borne shipping and breeding, and so on. The final stage involved diversion of water across the Huang He and Huai He to accomplish the task of transferring water from south to north Shaanxi.

Based on the tasks set out in the Han Jiang basin plan, plans were made to make the key Danjiangkou water conservancy project the first phase project in development of the Han Jiang's water resources. After 1962, the State Council decided to adopt a phased construction arrangement, with the scale in the initial stage of the project to involve construction of a 162 meter-high dam. Construction of the project began in September 1958 and the No 1 generator began generating power in October 1968. The entire project was completed in early 1973. In the 1960's, after doing the corresponding supplementary research based on new conditions, a development program was proposed for the trunk of the upper Han Jiang. After the 1970's, the Beijing Survey and Design Academy and Northwest China Survey and Design Academy conducted survey, planning, design, and experiment work in the upper Han Jiang and did a great deal of preparatory work for Shiquan, Ankang, Xihe, Xunyang, and other hydropower stations. Beginning in early 1970, some builders in the 4th Engineering Bureau of the former Ministry of Water Resources and Electric Power left Lijia Gorge and arrived in the upper Han Jiang to prepare for construction of Shiquan hydropower station and construction began in November 1970. The No 1 generator began generating power in December 1973. After the project was basically completed in July 1975, they began preparing for construction of the large Ankang hydropower station. Excavation of the banks for the large dam began in April 1978, and in December 1983 the flow was victoriously diverted, after which foundation dredging and pouring of the concrete for the dam segment of the riverbed was carried out. Through the arduous labor of survey, design, scientific research, and construction personnel, the gates were lowered to store water at Ankang hydropower station in December 1989, the No 1 generator produced power in 1990, and full completion is planned for 1992.

Reviewing plans for the section of the trunk in the upper reaches of the Han Jiang and design, construction, and operation practice at Danjiangkou and Shiquan hydropower stations, and particularly the experiences in

construction of Ankang hydropower station on a section of the river with narrow terrain, complex geological conditions, and surging floodwaters flowing down steep slopes, we gained a deeper understanding of the laws of hydropower construction on the segment of the trunk in the upper Han Jiang and the status and role of cascade development of the upper Han Jiang in national economic development. These three hydropower stations were all built according to goals and development sequences set out in the Han Jiang basin plan. They have a total reservoir capacity of 24.74 billion cubic meters, their power stations have a total installed generating capacity of 1,835MW, and they generate an average of 7.26 billion kWh of power annually, equal to 55 percent of the developable hydropower resources on the trunk. Practice has proven that the deployment of these three hydropower stations conforms to the development program set forth in the basin plan and that it has outstanding comprehensive utilization benefits. The status, role, and benefits of these three hydropower stations have already been reported in SHUILI FADIAN (see issue No 11 for 1985, No 7 for 1986, and No 11 for 1990), so they will not be discussed in detail in this article due to space restrictions.

To take full advantage of the abundant hydropower resources and water-borne shipping resources on the trunk of the upper Han Jiang within the borders of Shaanxi Province and make them serve Shaanxi's economy as soon as possible, we must respect the principles of unified planning, comprehensive development, unified consideration for all aspects, and working toward the goal of optimum economic, social, and environmental benefits for the national economy as a whole, make major efforts to develop hydropower and develop water-borne shipping, and give consideration to irrigation, flood prevention, aquaculture, breeding, environmental protection, and other areas.

## II. Prospects for Hydropower Construction on the Trunk of the Upper Reaches of the Han Jiang

The Beijing Survey and Design Academy has done a great deal of work on hydropower construction on the trunk of the upper Han Jiang. In the past few years, they completed the "Report on a Cascade Development Plan for the Trunk of the Upper Reaches of the Han Jiang" and compiled the "Preliminary Feasibility Research Report for the Xihe Key Water Conservancy Project", and they are now doing preliminary design work for Xunyang hydropower station. This preparatory work has created favorable conditions for building large and medium-sized hydropower stations on the trunk of the upper Han Jiang.

A. Develop hydropower, develop water-borne shipping, invigorate Shaanxi's economy

The upper Han Jiang has abundant hydropower resources and water-borne shipping resources as well as favorable conditions for integrating hydropower construction with development of water-borne shipping.

However, because system loads have grown rather quickly in the past few years, power source construction has lagged behind the requirements of national economic development, which has led to a severe power shortage in the Shaanxi Grid.

Plans indicate that demand for power in the Shaanxi Grid in the year 2000 will reach 40 billion kWh and the maximum load will be 6,600MW. The expected peak-to-valley differential in the year 2000 will be 2,240MW and if we include rotating reserve capacity, the required peak regulation capacity will be 2,860MW. Among peak regulation power sources, hydropower and thermal power combined have a peak regulation capacity of 2,240MW, so there will be a 620MW shortage in peak regulation capacity.

As the national economy has grown rapidly, communication and transport volumes will continue to grow in the short term and existing communication facilities will be unable to shoulder the burden. Moreover, the Han Jiang connects southern Shaanxi with western Henan and northwestern Hubei and connects with the Chang Jiang further down, and thereby offers passage to Hunan, Sichuan, Jiangxi, Anhui, Jiangsu, Shanghai, and other areas. It is located exactly between the coal producing provinces (autonomous regions) of north China and the coal-short provinces (autonomous regions) of south China, so it is an ideal route for "shipping north China's coal to south China". According to water-borne transport plans, in the short term Ankang and above will be opened to 50 ton-grade vessels and the section from Ankang to Yunxian County will be open to 100 ton-grade vessels. However, because we have neglected water-borne shipping construction on interior rivers for a long time, the river channels are basically in a natural state, with many shoals, rapid currents, small bend radii, low vessel channel standards, and poor passage capacities. Added to the poverty and backwardness of the region of the upper Han Jiang, industrial and agricultural production is underdeveloped and abundant mineral resources have not been developed and utilized, so the development of water-borne shipping resources and regional economic development in the upper Han Jiang have been restricted.

To reduce the serious power shortage in the Shaanxi Grid and shortages of transportation for coal resources, especially following completion of the Xian-Ankang railroad, and open new flow divider channels for shipping Shaanxi's coal southward and eastward and expand supplies of energy resources in southcentral and east China, and for development and transportation of the river basin's mineral resources, we should develop hydropower on the trunk of the upper Han Jiang and develop water-borne transport on the upper Han Jiang as soon as possible. In the short term, we should focus on control of dangerous shoals in conjunction with hydropower cascade development and use reservoir regulation and storage to increase the shipping depth during the dry season. In the long term, on the basis of constructing cascade hydropower stations, building dams to

store water, submerging dangerous shoals, and channelizing water-borne transport, we should make a fundamental change in the natural state of shipping channels in the upper Han Jiang and turn the upper Han Jiang into an important hydropower base area for Shaanxi Province and open up arteries to the north and south and to the east and west.

Development of hydropower on the upper Han Jiang should be closely integrated with the development of water-borne shipping on the upper Han Jiang and use development of hydropower resources to promote development of industrial and agricultural production and canalization and improvement of shipping channels. We should use development of water-borne transport resources to promote development of mineral resources and exchange of materials, and these should be mutually complementary and mutually promoting to foster Shaanxi Province's resource advantages and invigorate Shaanxi's economy.

#### B. Broad prospects for hydropower construction on the trunk of the upper reaches of the Han Jiang

Of the seven hydropower stations already planned, those still awaiting development are Xunyang, Xihe, Shuhe, Jiahe, and Huangjin Gorge hydropower stations with a total installed generating capacity of 10,450MW, equal to 52.8 percent of the developable capacity on the trunk of the upper reaches. In March 1990, higher authorities examined and passed the "Report on a Cascade Development Plan for the Trunk of the Upper Reaches of the Han Jiang". Added to experience gained in building Danjiangkou, Shiquan, and Ankang hydropower stations and the enormous comprehensive utilization benefits gained from these hydropower stations, the superiority of the hydropower in the upper Han Jiang is gradually being realized by more and more people. Looking at the future of hydropower construction on the upper Han Jiang, there are broad prospects and many favorable conditions: 1) The state recently formulated some new policies biased toward hydropower. The "Industrial Policy Implementation Measures for the Energy Resource Industry" recently promulgated by the Ministry of Energy Resources stipulates: "give preference to the development of hydropower, increase the proportion of hydropower in our energy resources, use at least 50 percent of the future electric power investments arranged by the state for hydropower". This provides guarantees for preferential development of hydropower. 2) The Ministry of Energy Resources is now formulating national short and medium-term development strategies for medium-sized hydropower stations and raising special capital funds for developing medium-sized hydropower stations. The state now provides investment subsidies of 500 to 700 yuan per kW that will help raise capital for hydropower construction and thereby promote the development of medium-sized hydropower stations. 3) Shaanxi Province has formulated the principle of "improving the central Shaanxi plain, actively developing south Shaanxi and north Shaanxi", which inevitably will promote rapid development of



hydropower resources and water-borne shipping resources on the upper Han Jiang. 4) For the five cascades still awaiting development on the trunk in the upper Han Jiang, excluding Jiahe hydropower station which would lie in both Shaanxi and Hubei provinces, all of the other hydropower stations are located within the borders of Shaanxi Province, which is advantageous for fully fostering initiative in Shanxi Province to develop hydropower and water-borne transport on the upper Han Jiang. 5) Reservoir inundation losses are small and there are no negative effects on the ecological environment. 6) Communication with outside areas is convenient. The Yang-An [Yangpingguan-Ankang] and Xiang-Yu [Xiangfan-Chongqing] railroads pass by not far from the dam site and there are highways and water routes that can be used. 7) There is a complete construction and living base area and a construction staff in the 3d Engineering Water Resources and Hydropower Bureau with powerful technical forces, a full complement of equipment, and rich experience. 8) Favorable conditions already exist for continuous cascade development. On the basis of considerable existing preparatory work, cascade development programs and near-term projects have already been clarified and no time should be wasted after Ankang in moving quickly to build Xihe and Xunyang hydropower stations to form reverse regulation reservoirs for Shiquan and Ankang hydropower stations, respectively. Continuously develop construction excavation, pouring, and installation of water current activities during construction of each cascade hydropower station to produce the benefits of shorter construction schedules, conservation of investments, and better results quickly.

### III. Proposals for Hydropower Construction on the Trunk in the Upper Reaches of the Huang He

The hydropower construction fund began implementing a "shift from allocations to loans" in 1981. Following reform of the economic system, special low-interest loans were eliminated and the annual interest rate on bank loans rose to 15 to 20 percent. However, the price of electricity was too low, so the capability of compensating those who developed power is rather poor and it is hard to attract investments. For this reason, I propose:

1. Implement a policy of "new prices for new power", raise capital from many areas, join together to develop power

Based on state document No 72 (1985) "Provisional Stipulations Concerning Implementation of Various Electricity Prices To Encourage Capital Raising To Develop Power", the price for power supplied to grids that is generated by new power stations is determined on the basis of costs, taxes, and reasonable profits to implement "new prices for new power" and attain the goal of "using power to develop power".

Adopt a method of raising capital from many departments and through many channels, open up capital channels and sources. Examples include requisitioning

an electric power construction fund and over-quota income energy resource and communication fund, bank loans, issuing electric power construction bonds, enterprise investment shares, and so on to guarantee construction capital and foster the initiative of all areas in the state, local areas, and enterprises.

2. Reform the electric power development and management system, promote sustained cascade development

Use operationalization of Ankang hydropower station as a turning point, organize an Upper Han Jiang Electric Power Development Company, and with state support and assistance, establish dynamic capital, form independent administration, self-responsibility for profits and losses, using power to develop power, and self-development mechanisms to gradually achieve development of other cascade hydropower stations on the upper Han Jiang. Use profits from power generation after Ankang hydropower station goes into operation in the near term, loan repayment depreciation funds, and loan repayment taxes as starting capital to develop two hydropower stations at Xunyang and Xihe. Before the two hydropower stations at Xunyang and Xihe are completed and begin generating power, the capital repaid after operationalization of Ankang hydropower station should be used first for construction of these two power stations and the remainder should be used to repay the loan principle and interest. Calculations indicate that at a price of 0.25 yuan/kWh for electricity supplied to the grid and a loan interest rate of 15.42 percent, Ankang hydropower station could repay the principle and interests on its loans in their entirety in the year 2002, while the two hydropower stations at Xunyang and Ankang could be fully completed before 2000.

Viewing the prospects for hydropower construction on the trunk of the upper Han Jiang fills us with confidence. We believe that if all areas merely adhere to the principle of reform and opening up, coordinate the development of hydropower with the development of water-borne shipping, unite in cooperation, and work hard for the prosperity of the country, we will certainly be able to push hydropower construction on the trunk of the upper Han Jiang into a new stage and make new contributions to alleviating the electric power shortage in Shaanxi, opening up flow division channels for transporting coal from south Shaanxi to east China, and promote development of the regional economy.

### Success of Southwest Hydropower Development Reviewed

916B0059A Beijing RENMIN RIBAO HAIWAI BAN  
in Chinese 22 Apr 91 p 3

[Article by reporter Liang Shutang [2733 2885 2768]: "Southwest Hydropower Development Benefits the People, Nationality Economy Develops, Masses Live and Work in Peace and Contentment, Build Several Large Power Stations To Form Many New Towns"]

[Text] Minority nationality people who lost their original cultivated land due to the government's construction of large hydropower stations have not seen their standard of living decline because of resettlement of their villages.

Southwest China has many minority nationalities. For historical and environmental reasons, however, several minority nationalities have lived a poor life of "slash and burn agriculture and living where they pleased".

Nevertheless, statistics indicate that southwest China is relatively rich in developable hydropower resources and has about two-thirds of the total in China. Three large river systems alone, the Lancang Jiang, Wu Jiang, and Hongshui He, have over 35,000 MW of developable hydropower resources.

Now, Manwan, Yantan, Tianshengqiao, and other large power stations are under construction here.

Ministry of Energy Resources vice minister Lu Youmei [7120 0147 2812] has indicated clearly that these hydropower stations are located in nationality regions and cannot damage the interests of the masses who live there.

After beginning construction of Manwan power station in Yunnan in 1985, over 3,000 residents of the reservoir region were moved out, some to new settlements over 100 kilometers away.

After the residents moved to new locations, relevant government departments provided money to help them reclaim cultivated land, build houses, build roads and canals to divert water for irrigation, and provided loans to assist them in planting sugarcane, fruit, and other commercial crops. A government official estimates that nearly 50 million yuan was spent to help population resettlement at this power station. He said, "construction of the power station will benefit local nationalities". Near these large power stations, construction departments have worked jointly with local governments to raise funds to build hospitals, schools, stores, movie theaters, and so on and peasants from the local area and other places have come to establish hotels, restaurants, clothing, and other service industries to gradually form new towns.

Manwan Town in Yunxian County which was built in conjunction with Manwan power station is an example. Town mayor Du Wenguang [2629 2429 0342], a member of the Bulang nationality, said that in the past, the only goal of the peasants here was getting enough to eat, but now major changes have occurred in their diets and clothing, and many have bought televisions, tractors, and so on.

In building Lubuge power station, another large power station in Yunnan, besides spending several 10 million yuan to arrange for resettlement of the local population, the power station is also providing nearly 1 million yuan each year in special funds for afforestation of the area around the reservoir. Nearby peasants of the Bulang

nationality have assumed responsibility for this work and can earn substantial income each year.

### **Development of Small-Scale Hydropower in Mountainous Areas of Great Benefit**

916B0059B Beijing RENMIN RIBAO in Chinese  
20 Apr 91 p 1

[Article by Central People's Broadcasting Station reporter Luo Guanxing [5012 6034 2502] and Xinhua Agency reporter Sun Benyao [1327 2609 1031]: "Li Peng Stresses Major Importance of Developing Small-Scale Hydropower Construction in Meeting With Comrades at Electrification Counties Work Conference, Second Group of 200 Initial Rural Electrification Counties To Be Built"]

[Text] State Council Premier Li Peng pointed out on 19 April 91 that a second group of 200 rural hydropower initial electrification counties planned for the Eighth 5-Year Plan are extremely important for further development of small-scale hydropower resources, bringing prosperity to people in mountainous regions, and reinforcing construction of spiritual civilization. He called on everyone to work together to handle this matter properly.

Premier Li Peng met with comrades at the National Electrification County Work Conference at Zhongnanhai on 19 April 91 and talked with some comrades about the issue of how to further develop rural small-scale hydropower.

During the Seventh 5-Year Plan, major accomplishments were made for the first group of 100 rural electrification trial counties. These 100 counties were poor counties which were the focus of state and provincial support and old revolutionary base areas with a total population of more than 30 million people. After the trials, these counties used development of local small-scale hydropower as a tap to promote comprehensive development of their economies. Power output grew by 125 percent in 5 years, the gross value of industrial and agricultural output rose by 168 percent, county financial income quadrupled, and net per capita incomes tripled.

The second group of 200 rural hydropower initial electrification counties to be built during the Eighth 5-Year Plan have a population of 70 million, and 153 of the counties are in nationality regions, state and provincial focused support poor counties, and old revolutionary base area counties.

Li Peng said during his meeting that work on the first group of 100 rural electrification trial counties has been fully completed. Now, it would appear that the state's implementation of this type of measure was successful and had promoted development of the rural economy in these regions, improved the lives of the people there, strengthened construction of spiritual civilization, conserved timber resources, and protected the ecological

environment. The summary just made by comrades that "if mountainous regions want to change, they must first develop small-scale hydropower, and with power, there will be prosperity everywhere" provided a very vivid and moving overview of experience in developing power in mountainous areas.

While discussing the achievement of initial electrification in the 100 trial counties, Li Peng said that although the state had provided definite support, it was done mainly by fostering the spirit of self-reliance and arduous struggle among the local popular masses, especially increased labor inputs, and the support provided by local governments and related departments. Relying on mobilization of the masses and taking the mass line is a superior tradition of the CPC. In this new historical stage, further development of small-scale hydropower and transformation of mountainous regions will require that we continue to foster this tradition. Policies like "self-construction, self-management, and self-use", "using power to develop power", and so on proposed for the first group of trial points conform to real conditions and were effective.

When discussing ways to achieve further development of small-scale hydropower in the future, Li Peng said that we should adapt to local conditions to develop and utilize local hydropower resources, work on easy projects first and hard ones later, and be concerned with results.

When discussing the relationship between small power grids and large power grids, Li Peng said that we must unite to develop power, large grids should support small grids, and small grids should be capable of enabling large

grids to operate according to scientific laws of the economy and gradually achieve standardization.

Li Peng stressed that development of rural small-scale hydropower will play an inestimable role in construction of spiritual civilization in rural areas. Only when they have power will we be able to bring radios and televisions into our vast rural areas and mountainous regions to enable over vast peasant masses to understand Chinese and foreign affairs, increase their cultural knowledge, and invigorate their cultural lives. Education via radio and TV can also train skilled agricultural technical personnel.

Li Peng congratulated the achievements made in the first group of 100 rural electrification trial counties and called for summarization of their experiences as a foundation for doing better work in the second group of 200 rural hydropower initial electrification counties.

Vice premiers Tian Jiyun [3944 4764 0061] and Zou Jiahua [6760 1367 5478], State Council secretary general Luo Gan [5012 1626], Ministry of Water Resources minister Yang Zhenhuai [2799 2182 2037], and others also attended the meeting and discussions.

At the discussion, Ministry of Water Resources minister Zhang Chunyuan [1728 2504 0954] introduced the situation at this work conference. Hunan Province Cili County mayor Shang Wu [1424 2976] and Sichuan Province Ganluo County mayor Qumu Chehe [2575 2606 6508 0735] spoke about conditions and experiences in their areas in counties which achieved initial electrification and ways to achieve further development of small-scale hydropower in the future.

### Nation's Largest Geothermal Plant Completed

916B0053B Beijing RENMIN RIBAO HAIWAI BAN  
in Chinese 8 Feb 91 p 1

[Article by reporter Liu Wei [0491 0251]: "Tibet Completes China's Largest Geothermal Power Plant, Yangbajing Completes and Places Into Operation Two More Generators, Total Installed Generating Capacity at This Power Plant Reaches 25MW"]

[Text] On 5 Feb 91, the No 4 and 5 generators at Tibet's Yangbajing geothermal power plant were completed, connected to the grid, and began generating power. This increased the installed generating capacity at this geothermal power plant to 25.18MW, the largest in China in power output, largest in installed generating capacity, and at the highest elevation above sea level in the world. This is an indication that development and utilization of shallow strata geothermal energy which has been underway for 16 years at this power plant has finally moved from the experimental stage to industrial power generation focused on production.

The Yangbajing region has a freeze period of more than 200 days and is over 4,300 meters above sea level. Over the past 16 years, the state has invested more than 200 million yuan and many provinces and municipalities in the interior of China have provided manpower, materials, and finances to support geothermal development. In 1975, China's first moist steam well was born at Yangbajing in Tibet. In 1977, China's first MW-grade geothermal power generator was successfully tested at Yangbajing and we created an international pioneer in the direct use of moderate and low temperature geothermal energy to generate power. Statistics on the installed geothermal generating capacity in each of the world's nations indicates that China holds 12th place worldwide.

For the past several years, geothermal experts in the United States, Japan, New Zealand, Australia, Italy, Iceland, and other countries and the United Nations Development Program have made several trips to Yangbajing to exchange technology and work. During the first phase, foreign countries invested \$4 million in international cooperation and during the second phase the United Nations provided \$5.15 million in assistance. Indications are that Chinese and foreign experts have discovered high temperature geothermal reserves over 200°C to the north of Yangbajing that have substantial development prospects.

During its operation, Yangbajing geothermal power plant has produced a total of 370 million kWh of power so far, making it Tibet's largest power plant at present, and it accounts for 40 percent of yearly power output in the Lhasa Grid.

### Harbin Thermal Power Equipment Plant Ranks Among World's Most Advanced

916B0053A Beijing RENMIN RIBAO in Chinese  
5 Feb 91 p 1

[Article by reporter Wu Peizhen [2976 1014 4176]: "Harbin Thermal Power Equipment Manufacturing Moves into World's Advanced Ranks, Can Produce 600MW Generators in Batch Amounts"]

[Text] China's largest power generation equipment production base area, the China Harbin Power Plant Equipment Set (Group) Company composed of the Harbin Boiler Plant, Electrical Machinery Plant, and Steam Turbine Plant, has made major achievements in technical upgrading which have moved China's thermal power equipment manufacturing into the world's advanced ranks.

The three large motive power plants in this group company received 305 million yuan in state investments during the Seventh 5-Year Plan to import the newest world technology of the 1980's to carry out large scale technical upgrading that passed state inspection and was accepted as meeting specifications on 4 Feb 91. During the entire upgrading process, the amount of capital spent was equivalent to just 1/3 the amount of fixed assets but it increased the thermal power equipment production capacity of these three plants 1.4-fold. Moreover, they can produce imported models of 600MW generators in batch quantities and their primary equipment and product technologies have all attained advanced international levels.

Transformation of these three motive power plants produced outstanding results. Testing indicates that, compared with three 200MW generators currently in an operational state in China, the 600MW generators can conserve 210,000 tons of coal annually and generate 140 to 210 million kWh in additional power. Moreover, the generators have long useful life spans, high automation levels, powerful controllability, and safer and more reliable operation. This major transformation has opened prospective international markets for China's power generation equipment and over 10 countries have come to China to place orders.

CPC Central Committee Politburo member and State Council member Li Tieying [2621 6993 2503] cut the ribbon at the examination and acceptance meeting and issued a certificate of inspection and acceptance for meeting specifications to the three motive power plants under the Harbin Power Plant Equipment Set (Group) Company and offered his congratulations on behalf of the State Council.



**Update on Liaoning Expansion Project**

916B0053C Beijing LIAONING RIBAO in Chinese  
27 Jan 91 p 1

[Article by reporter Li Dan [2621 0030]: "Liaoning Power Plant Second- Phase Expansion Project Reports Victory, It Moves Into the Ranks of 1,000MW Large Power Plants"]

[Text] On 23 Jan 91, two 200MW generators at the Liaoning power plant second-phase expansion project went into operation and began generating power. This moved Liaoning power plant into the ranks of large 1,000MW power plant enterprises.

On 25 Jan 91, the Northeast China Power Management Bureau held a meeting to commend the operationalization at Liaoning power plant. State Ministry of Energy Resources vice minister Shi Dazhen [0670 1129 2823], Liaoning Provincial Political Consultative Conference chairman Xu Shaofu [1776 1421 3940], Liaoning Provincial vice governor Lin Sheng [2651 5116], and others made a special trip to Liaoning power plant to participate in the ceremonies.

Formal construction of the second-phase expansion project at Liaoning power plant began on 1 Jun 88. Builders from the East China No 1 Power Company and other units responsible for project construction worked in winter snow and the summer sun to defeat numerous

difficulties and worked day and night to complete the expansion tasks with superior quality and high speed. They attained the goal set forth by the Liaoning Provincial Government 7 months ahead of schedule and created a good achievement of placing two 200MW generators into operation in northeast China in 1 year.

In his speech, Liaoning Provincial vice governor Lin Sheng commended the East China No 1 Power Company as a bold and vital army on the electric power capital construction battlefield in northeast China that was capable of fighting a hard battle. They cooperated closely with fraternal companies and made outstanding achievements in developing Liaoning's electric power industry.

Lin Sheng said that to achieve sustained, stable, and coordinated development of Liaoning Province's economy, the Liaoning Provincial CPC Committee and Provincial Government have decided to accelerate development of Liaoning Province's electric power industry. During the Eighth 5-Year Plan, they will complete three big power plants at Tieling, Yingkou, and Dalian and ensure that 800MW of generators are placed into operation each year, so the tasks are extremely arduous. He hoped that, faced with new tests, the builders will focus on ensuring project quality, shortening construction schedules, and reducing project costs, continually raise construction management levels, and achieve the electric power industry's development goals for the Eighth 5-Year Plan.

### **Tarim Exploration Achieves Major Results**

916B0061B Beijing RENMIN RIBAO HAIWAI BAN  
in Chinese 18 Apr 91 p 1

[Article by reporters Shen Zunjing [3947 1415 2417] and Li Shengjiang [2621 3932 3068]: "Major Achievements in Exploration and Development of Tarim, Substantial Reserves May Be Found Shortly"]

[Text] We learned from the Tarim Petroleum Exploration and Development Headquarters on 17 Apr 91 that over 10,000 petroleum employees have made five major achievements after 2 years of arduous exploration and development of Xinjiang's Tarim Basin.

1. A development and production experiment region has basically been completed and outfitted near the Lunnan Nos 2 and 3 wells in the northern part of the basin. Its daily output is more than 1,300 tons of crude oil. With the additional continued expansion of development of the surrounding area, a yearly crude oil production capacity of 1 million tons may be formed.

2. In the eastern part of the Tazhong [central Tarim] structure in the middle of the Taklimakan Desert, after obtaining daily outputs of 576 cubic meters of crude oil and 340,000 meters of natural gas flows at the Tazhong 1 well, exploratory drilling of the Tazhong 5 well now in progress has found rather good indications of oil and gas and important new discoveries may be made.

3. Industrial oil and gas flows have already been obtained from 23 exploratory wells between the Lunnan fault-fracture zone and Sangtamu fault-fracture zone, confirming that this region has four sets of high output oil and gas strata that have formed a preliminary situation of different overlapping petroliferous strata.

4. High output oil and gas wells have been drilled in two structural traps in the Yingmaili region. It has now been confirmed that this region is a group of large formations with conditions that are rather conducive to oil generating and reservoiring and there is a possibility that substantial reserves and a petroliferous area may be found.

5. Carboniferous system sandstone oil strata 100 meters thick have been found in the Donghetang region in the central section of the Tabei [north Tarim] uplift. After completion of the well and testing of the oil, daily output is 837 cubic meters of crude oil.

Further exploratory drilling may produce a set of high output high abundance large oil and gas pools in this region.

Qiu Zhongjian [6726 0022 1696], who holds concurrent posts as assistant general manager of the China Petroleum and Natural Gas Corporation and commander of the Tarim Petroleum Exploration and Development Headquarters, told us that "these conditions show that substantial advances have been made in petroleum exploration and development in the Tarim Basin and

that petroleum reserves on a substantial scale may be found soon that will be constructed into significant production capacity".

### **Tarim Holds Country's Largest Ocean-Facies Oil Field**

916B0061A Beijing RENMIN RIBAO HAIWAI BAN  
in Chinese 7 May 91 p 3

[Article by reporter Qu Zhi [2575 4160]: "First Large-Scale Investigation by Chinese Academy of Sciences Discovers that Tarim Contains China's Largest Marine Facies Oil Deposit"]

[Text] Tarim Basin, located in northwest China far from the ocean and deep in the Chinese interior, contains China's only and largest marine facies oil deposit on the Chinese continent. This startling discovery was made by the first investigation of the Tarim Basin by the Chinese Academy of Sciences.

All the oil deposits previously discovered on the Chinese mainland like Shengli, Daqing, Zhongyuan, and so on are continental facies oil deposits.

Scientists from the Lanzhou Geology Institute, which was responsible for this comprehensive investigation, stated that petroleum generation in Tarim has a close and inseparable relationship with stable sedimentation in a marine area and several instances of large-scale marine intrusion during the Protozoic era which formed conditions favorable to oil generation. This is unlike the other large oil deposits in China.

Geologists think that the discovery of this marine facies-generated oil deposit is extremely important for enriching and filling out Chinese geology.

Tarim Basin covers an area of 560,000 square kilometers and is China's largest continental basin as well as one of the world's most famous desert basins.

Scientists in the investigation team said that the uniquely evolving formations determined that Tarim Basin would have typical marine lithification characteristics. It underwent three large-scale marine intrusions and one lacustrine expansion from the Cambrian period 600 million years ago to the Jurassic period 100 million years ago, after which it underwent one intrusion by ancient sea water.

These marine intrusions inundated nearly all of the Tarim paleocontinental block and each advance and regression of water and the amount of the water caused this paleocontinental block to go through a series of geomorphological changes from a sea, shallow sea, lake, tidal flat, and so on which also promoted the development and multiplication of ancient organisms during various periods.

Scientists in the investigation team discovered a history of flourishing life in Tarim Basin from fossils preserved in the various rock strata in the basin. They said that as

early as the initial periods of the birth of life on the Earth, many paleomicroorganisms had appeared in Tarim. These organisms provided the material guarantees for the formation of oil and gas in Tarim.

The elimination of organic life by Tarim Basin's arid climate and the desertification of its environment was caused after the overthrust and compression of the Himalayan activity during the past 5 million years and it did not appear until it was uplifted into its present-day position.

The scientists feel after a 4-year detailed investigation that lasted from 1986 to 1990 that the abundant organic material and unique structural environment created abundant reserves in this oil deposit beneath the Tarim Basin desert and that most of it is reservoirized in an area about 5,000 meters below ground. It is well-preserved and is one of China's big oil deposits with very good prospects.

The Science Press recently published the research results of this investigation.

#### **Structural Feature and Oil Exploration Strategy in Kailu Region**

40100044B Jiangling SHIYOU YU TIANRANQI  
DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 12  
No 1, Mar 91 pp 42-51

[English abstract of article by Jiang Xiaoxia and Deng Rongxiu of the Bureau of Geophysical Prospecting, China National Petroleum Corporation]

[Text] Kailu Region in the south part of the Songliao Basin is a Meso-Cenozoic sedimentary province that covers an area of  $3.2 \times 10^4$  km<sup>2</sup> and developed the Upper Jurassic Series, Cretaceous and part of Tertiary Systems. The sediments that overlaid the Proterozoic-Paleozoic metamorphic basement reached a maximum thickness of 4,500 m. The Kailu Region underwent four tectonic evolution stages that are tensional faulting, fault-subsiding, depressing and compression-shearing, and can be divided into 5 first order tectonic units and 14 secondary tectonic units.

A series of elongated contemporaneous normal faults that stretches NNE or NW with big vertical throws and a group of separate graben-like lake basins in which igneous rocks developed in the early stage and shore-shallow lake sediments in the late stage formed in the Jurassic due to the underthrusting of the Pacific Plate and the updoming of mantle. Faulting basically stopped in the Early Cretaceous and the whole region subsided under isostatic effect, resulting in stable extensive shore-shallow lake deposits. From Late Cretaceous to Tertiary, the variation of regional stress field caused horizontal compression on the southeast margin, thus forming northeast trend surface folds and causing particular normal faults to reversal.

There are thick dark mudstones in the Jurassic (occupying 60-90 percent of the total thickness), which has rich organic matter (organic carbon 2-3 percent), type-I and type-II of kerogen and widespread oil-gas shows. The threshold depth for oil generation is 1,300 m. It is considered that the Jiufotang and Shahai Formations are the main oil-generating intervals, and the Lujiabao Depression, Bao'an and Naimanqi Sags in the Zhezhong Depression are the most prospective regions for hydrocarbon exploration.

#### **Structural Feature and Hydrocarbon Potential of Zhoukou Depression**

40100044A Jiangling SHIYOU YU TIANRANQI  
DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 12  
No 1, Mar 91 pp 10-20

[English abstract of article by Wang Dingyi, Liu Chiyang, and Zhang Guowei of the Department of Geology, Northwest University, and Ma Jinyu, Yu Mengzhen, and Zhang Hongkui of the Bureau of Petroleum Exploration, Henan]

[Text] Zhoukou Depression that crosses the two different tectonic units of North China massif and the southern marginal structural belt of the North China massif is the biggest depression covering an area of 32,000 km<sup>2</sup> in the south part of North China Basin. In the Mesozoic, NWW-trend tensile and compressive sags that filled with rapid accumulated volcanic-clastic rocks and oil-bearing molass formations developed in Runan, Tanzhuang-Shengqiu regions due to intracontinental volcanic activities and A-type subduction caused by continent-continent collision of North China Plate and Yangzhi Plate. In the Eogene, an arc-shaped tectonic framework protruding to south as a whole in the depression was controlled by tensile-wrench stress field. It contains 2 uplifts alternated with 3 sags, including North part sag zone, Linying-Dancheng uplift zone, Central sag zone, Pingyu-Taihe uplift zone and South part sag zone from north to south. Each of the sag zones is made up of several dustpan-shaped sags. It formed a group of dustpan-shaped sags with multi-depocenter and multi-hydrocarbon generation center. The tensile-wrench arc-shaped tectonic system resulted from combined acting of dextral shear-wrench movement of Xiaoyi-Woyang-Macheng fault in Tanlou fault zone with sinistral shear-wrench movement of NWW trend fault in this region.

Comprehensive studies indicate that the Central sag zone is favourable for hydrocarbon exploration in the future. The Mesozoic System in the South sag zone and the Lower Paleozoic System in the North sag zone are prospective, and worthy to be further studied.

**Hydrocarbon Prospects of Cenozoic System in Turpan-Hami Basin From View of Organic Matter Evolution**

40100044C Jiangling SHIYOU YU TIANRANQI  
DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 12  
No 1, Mar 91 pp 79-88

[English abstract of article by Wu Weiwen of the 05 Project Administration, Southwest Bureau of Petroleum Geology and Fu Heng of the Northwest Bureau of Petroleum Geology]

[Text] The Jurassic was the prime period in the development of Turpan-Hami Cenozoic continental Basin. The Early and Middle Jurassic was lake transgressive sedimentary stage and source rocks developed well; the late Middle Jurassic and Late Jurassic was lake regressive sedimentary stage in which reservoir and cap rocks developed. Jurassic depocenters and subsiding centers were in North, Toksun-Shanshan and Wubu Sags. The first one is the main oil-generating sag, organic matter in Lower Jurassic source rocks of which began to generate oil in Late Jurassic and reached oil-generating peak in the Eocene, whereas that of the last two sags still in lower matured or immature stages. The structures within the basin, including Kokyar anticline belt in the North Sag, the west Yanmu-Huoyanshan anticline belt of Huoyanshan-Sandaoling uplift formed primarily in late Yanshanian-Himalayan Epochs, matched well with the oil generating phase of Lower Jurassic source rocks in time and space, and were favourable for hydrocarbon migration and accumulation. So the structures mentioned above are the most prospective areas for Mesozoic hydrocarbon. Qiktai and Shengjinkou anticline oil pools situated in Huoyanshan anticline belt are the examples of this kind, followed by Toksun-south Shanshan and Wubu Sags. Yanshan and Dadun structures in west Yanmu anticline are favor [as published] to trap hydrocarbon generated from both sags in the north and south.

**Old Yanchang Oil Field Still Producing**

40100049A Beijing CHINA DAILY (Supplement)  
in English 21 May 91 p 2

[Text] The oldest oilfield on China's mainland has been surging with new gushes of oil in the last 10 years, yielding 1.94 million tons of crude petroleum between 1981 and 1990.

The output is three times the total drilled out since the oilfield spouted its first gush of petroleum in 1905, according to the director of the Yanchang Petroleum Field Administration in north China's Shaanxi Province.

The output growth rate in the latest 10 years averaged 18.7 percent.

Director Gao Pengfei said that output of crude oil this year is expected to reach 430,000 tons.

Gao said the output of crude oil from this old oilfield will continue to surge as prospecting has proved there is a deposit of 140 million tons covering 350 square kilometres.

Situated on the Loess Plateau and 70 kilometres from Yan'an City of Shaanxi Province, this 86-year old oilfield holds a rich deposit of high-quality petroleum buried fairly shallowly under the ground.

Gao said the favourable drilling conditions at the oilfield have encouraged his administration to invest an average 1 million yuan (\$192,000) each year to develop oil production there in the past 10 years.

Presently, four drilling sites and two refinery factories have been set up, Gao said. The administration has eight drilling companies working on the oilfield.

Industrial output value at the oilfield last year hit 212.52 million yuan (\$40.87 million), eight times that of 10 years ago.

The oilfield was the biggest profit earner and State revenue contributor among enterprises in the province last year when its profits registered 161 million yuan (\$30.96 million), 22 times that of 10 years ago.

The administration handed to the central government 65 million yuan (\$12.5 million) in revenue, 12 times that of 10 years ago.

It also exported \$2 million worth of petroleum products in the past few years.

Gao attributed the encouraging development of this old oilfield to efficient use of funds.

Between 1980 and 1990, the administration managed to obtain funds totalling 621.41 million yuan (\$119.45 million), of which 25.39 percent came from government investment, 50.12 percent was self-raised capital and 24.5 percent was bank loans.

Most of the funds were invested in building two refinery factories that earn high interest, Gao said.

The two projects went into production in 1988 and have turned out 139.96 million yuan (\$26.41 million) in industrial output value, or 7.4 million yuan (\$1.4 million) in profits in the past two years.

The two refinery factories have proved to be the major profit earners and "we counted on them to pay off bank loans," Gao said.

To advance technology and innovate the old equipment is another effort in bringing about a drastic development of this oilfield.

The effort is two-pronged, seeking co-operation from domestic research institutes to work on solutions to some technical difficulties and introducing advanced equipment from abroad.

Two drilling kits imported from the United States in 1984 have helped greatly in sinking new wells, Gao said.

Cutting down on non-urgent capital construction projects and reducing production costs are also important to the new developments, Gao noted.

As a result, the administration reduced expenses by 7 million yuan (\$1.32 million) and slowed the growth rate of production costs last year, Gao said.

The administration has set a target to slash expenses by 8 million yuan (\$1.51 million) and slow down the production costs by 2 percent this year, Gao said.

The administration has also set targets for an overall development of this old oilfield for the coming five and 10 years.

Output and prospecting for more oil deposits will be increased, Gao said, adding that improvement in quality of refined oil products will also be sought.

Prospecting will be carried on in 120 square kilometres to locate two more sites for sinking oil wells on 40 square kilometres. The target for the proved petroleum deposits from this planned prospecting is 55 million tons.

The administration expects to increase petroleum output to 580,000 tons in 1995, 45 percent more than the output in 1990.

According to those targets, the administration needs to organize a total drilling of 940,000 metres by the end of 1995, sinking 1,710 oil wells, of which 1,531 wells are to be put into production.

The targets for producing refined oil products include putting out 409 tons of refined oil products, of which 308.87 tons are to meet high quality standards. The yearly refining capacity of this administration is to reach 1 million tons as compared with the current 700,000 tons.



**Energy Minister Says Country To Be Self-Sufficient in Nuclear Power Technology in 10 Years**

916B0060 Beijing RENMIN RIBAO in Chinese  
2 Apr 91 p 4

[Article by reporter Sun Jie [1327 2638]: "Huang Yicheng Tells Chinese and Foreign Reporters at 'Two Associations' News Center that China Will Gain a Quick Grasp of Nuclear Power Plant Construction Technology in Next Decade, State Will Provide Preferential Investment Guarantees for Unified Distribution Coal Mine Construction"]

[Text] Minister Huang Yicheng [7806 3015 6134] stated at a reception for reporters held in the "Two Associations" News Center at the Beijing Broadcasting Building on 1 Apr 91 that China will gain a quick grasp of nuclear power plant construction technology over the next 10 years and try to achieve a rapid transition to domestic production of nuclear power equipment to create the conditions for faster development of nuclear power in China after the year 2000.

When answering reporters' questions concerning nuclear power plant construction in China, Huang Yicheng said that China will make major efforts to develop nuclear power, especially in the energy-short southeast coastal region. China will basically rely on its own forces to establish the 300MW Qinshan nuclear power plant. This nuclear power plant may begin generating power during 1991. Over the next decade, China plans to design and manufacture several 600MW nuclear power plants to gain an understanding of nuclear power equipment manufacturing technology and will strive to make a shift to basically domestic production of nuclear power equipment by the end of this century. Recently, Guangdong Province proposed building two nuclear power plants to meet its economic development needs, but because site selection and capital sources have not been implemented yet, this project was not included in the energy resource development plan for the Eighth 5-Year Plan.

Some reporters asked whether or not construction of the Three Gorges project would begin during the Eighth 5-Year Plan. Huang Yicheng said that demonstration work for the Three Gorges project has just concluded and that the State Council was organizing experts to examine the demonstration report. Even if the State Council examines and passes this demonstration report, it still requires approval by the National People's Congress before construction can begin. Thus, the Three Gorges project was not included in the Eighth 5-Year Plan.

When responding to questions concerning cooperation with foreign countries to develop China's energy resources, Huang Yicheng pointed out that China has already announced that 11 provinces can cooperate with foreign countries to develop continental petroleum. China has invested large amounts of manpower and

materials over the past several years to explore the oil and gas resources of the Tarim Basin and basically clarified the geological structure of the Tarim Basin. Because China is basically self-sufficient in petroleum equipment and has cheap labor, China does not plan to adopt a cooperative arrangement like the one used for development of off-shore petroleum when it cooperates with foreign countries to develop Tarim oil deposits. Huang Yicheng said that China now exports over 20 million tons of crude oil annually and it is unlikely that petroleum exports will expand in the future.

Huang Yicheng also introduced the primary measures for future development of China's energy resource industry at the reception for reporters. He said that in the future, the state will provide preferential investment guarantees for construction of unified distribution coal mines and will accelerate development of coal in the northeast China region in an effort to reduce shipments out of Shanhaiguan as much as possible. Moreover, each year during the Eighth 5-Year Plan we will have to increase crude oil output by 2 million tons and add 10,000MW in large and medium-sized hydropower installed generating capacity, and we will have to build about 30,000MW of pit-mouth power plants over the next 10 years.

**Prospective Development of High-Flux Engineering Test Reactor**

91FE0405 Chengdu HE DONGLI GONGCHENG  
[NUCLEAR POWER ENGINEERING] in Chinese  
Vol 11, No 6, 10 Dec 90 pp 6-10

[Article by Wu Yinghua [0702 5391 5478], Bu Yongxi [0592 3057 3556], and Hong Yonghan [3163 3057 3352] of the Southwest China Reactor Engineering Research and Design Academy, Chengdu: "Prospects for the High-Flux Engineering Test Reactor"; manuscript received 17 Jul 90]

[Text]

**Abstract:** This article describes development prospects for the high-flux engineering test reactor (HFETR). The focus in development and utilization of the HFETR is on irradiation experiments with nuclear power plant and power reactor fuel elements and assemblies and basic research on topics in the fields of high technology and nuclear power. The depth and breadth of reactor comprehensive utilization has been opened up in the areas of isotope development and production, source matching and applications, and irradiation processing. The HFETR has been included in state S&T development plans, and perfection of the device will allow it to serve as a national laboratory open to China and foreign countries.

**Key terms:** HFETR, irradiation experiments, isotope processing, national laboratory, development prospects.

## I. Introduction

To develop China's atomic energy industry, meet the need for experimental research on nuclear power fuel element and materials irradiation, promote a shift to domestic production for nuclear power and application of nuclear technology in all realms of the national economy, serve as a key state engineering and construction project, and rely totally on China's own technical and industrial strengths, we basically completed the high-flux engineering test reactor at the end of 1980 along with the associated research and auxiliary facilities, and it has now been operating safely for 10 years. Since it began operation, the reactor has completed irradiation experiment research tasks for several types of nuclear materials and fuel samples. We developed and produced  $^{60}\text{Co}$ ,  $^{192}\text{Ir}$ ,  $^{170}\text{Tm}$ ,  $^{99\text{m}}\text{Tc}$ ,  $^{113\text{m}}\text{In}$ , and other high specific activity radioactive isotopes with medical, industrial, and agricultural applications. This filled in a blank space within China and reduced substitute imports. Gratifying progress has been made in the area of reactor comprehensive utilization.

The HFETR is the largest research and experimental reactor at relatively advanced levels in Asia at the present time in reactor power scale, neutron flux levels, irradiation experiment capabilities, and other areas. Only a few countries in the world like the United States, the Soviet Union, and a few nations with advanced nuclear technology in Western Europe have such a large reactor of this type. Because the corresponding test loops were not constructed when the reactor was built and for financial expenditure and other reasons, the capabilities and uses of the HFETR have not yet been rationally fostered and fully utilized. This should receive the concern and attention of the relevant departments of the state and people in all areas to enable the HFETR to play the even greater role it should play in China's nuclear industry and scientific development over the next 10 to 20 years.

## II. A Focus on Ensuring Nuclear Fuels and Materials Irradiation Experimental Research

The HFETR has a high neutron flux, short irradiation experiment cycle, large irradiation space, flexible configuration, strong reactivity, and other characteristics. The design power of the reactor is 125MW. The maximum thermal neutron flux of the reactor core is  $6.2 \times 10^{14} \text{ n/cm}^2 \cdot \text{s}$  and the maximum fast neutron flux ( $E_n$  0.625 eV) is  $1.7 \times 10^{15} \text{ n/cm}^2 \cdot \text{s}$ , which are 5 to 10 times higher than regular test reactors in China. The core design allows configuration with five large irradiation ports ( $\phi$  150) and four small irradiation ports ( $\phi$  63). Single flow process irradiation experiment devices can be installed in three of the  $\phi$  150 ports. Four large irradiation ports (two  $\phi$  230 and two  $\phi$  122) also can be configured in the reflection layer. There are also several holes in the beryllium blocks and aluminum blocks and holes in the elements that can be used. The irradiation thermal neutron flux is  $2 \times 10^{13}$  to  $5 \times 10^{14} \text{ n/cm}^2 \cdot \text{s}$  and the fast neutron flux ( $E_n$  0.625 eV) is  $1 \times 10^{13}$  to  $1.6 \times$

$10^{15} \text{ n/cm}^2 \cdot \text{s}$ , of which the  $E_n$  1 MeV fast neutron flux is  $1 \times 10^{12}$  to  $5 \times 10^{14} \text{ n/cm}^2 \cdot \text{s}$ . If a water cavity is configured in the center of the core, the thermal neutron flux can be greater than  $1 \times 10^{15} \text{ n/cm}^2 \cdot \text{s}$ . The irradiation reaction inspection facility built into the HFETR is the largest in scale and most basically matched in China. It includes 13 hot rooms and 20 semi-hot rooms for dissection and breakdown, non-destructive inspection, mechanical and physical properties testing, metallic phase and materials chemistry, isotopes, and so on. It also has research laboratories for nuclear physics, radiation chemistry, coolant chemistry, isotopes, irradiation technology, irradiation protection, environmental monitoring, radiation counting second-stage station, and so on. The HFETR is the most powerful neutron irradiation experimental research tool in China. By the end of this century and the beginning of the next century, the HFETR should be playing a leading role in irradiation experimental research centered on nuclear fuels and materials.

A 500 kW high-temperature high-pressure water loop has now been built and large scale irradiation inspection of small fuel assemblies ( $4 \times 4 - 4$ ) for nuclear power plants will be carried out soon. It is expected that when the first phase of the inspections is completed, the maximum average fuel consumption of the single rods in the assemblies could reach 40 GW.d/t(U). When the second phase of the inspections is completed, the maximum average fuel consumption of the single rods in the assemblies could be as high as 51 GW.d/t(U), which are equivalent to the average unloaded fuel consumption of 35 GW.d/t(U) and 42 GW.d/t(U) at Daya Bay Nuclear Power Plant. At that time, the fuel consumption of the high-performance fuel rods will approach 60 GW.d/t(U). Completion of this large comprehensive inspection will provide complete data on high fuel consumption properties and make important contributions to the safety and economy of nuclear power plant operation in China and the shift to domestic production of fuel assemblies.

The HFETR has prepared specific conditions for experimental research on high-temperature gas-cooled and sodium-cooled fast reactors. A large pressurized-steam generator equipment foundation is installed between the four irradiation loops at the - 6.5 m high mark in the main plant building. In the area of the reactor structure, the proper conditions were also left for installing a fully-enclosed sodium irradiation device. Looking at the long-term plans for nuclear power development, we should arrange for loop irradiation experiment tasks for new reactor types as soon as possible.

The HFETR uses highly enriched uranium as a fuel. It has a large effective breeding coefficient and a relatively large irradiation sample capacity. The core is a water-deficient dense grid with a harder energy spectrum than heavy-water reactors and swimming pool light-water reactors. Moreover, the loading configuration can be used to make local readjustments in the energy spectrum. For example, local increases in beryllium blocks will soften the neutron spectrum, while using Cd or B<sub>4</sub>

casings to absorb neutrons can increase the fast neutron to thermal neutron ratio. This, in addition to the high neutron flux and short irradiation cycle, provides enormous advantages for materials irradiation. Post-irradiation properties data can be obtained within a short time period, which greatly accelerates the pace of new materials development and type determination.

During the Eighth 5-Year Plan, topical research in the realm of nuclear power determined by the State Science and Technology Commission in its high-tech development plan will get underway fully. All sorts of irradiation experiments and properties measurement research will be done on new materials (including element cladding, reactor structure, reflection layers, screens, and other materials) for high-temperature gas-cooled reactors, fast reactors, and fission-fusion reactors and on fuel samples to lay a foundation for development of nuclear technology in China in the 21st Century. Pressurized-water reactors, the primary reactor type in China at present, should match up further with scientific research, design, and production, continue to carry out irradiation properties research on a new generation of structural materials and special reactor materials, fully achieve a shift to domestic production of reactor materials, and improve the economic and technical indices and safety indices of nuclear power plants and power reactors. Intensive development of basic and applied research in nuclear materials science also will directly promote development and perfection of China's metallurgical, machinery, chemical, and other basic industries and make a contribution to the establishment of China's own complete nuclear power equipment manufacturing capability.

Moreover, research will be done at the HFETR on the use of  $U_3Si_2$ -Zr dispersed plate elements, burnable poisons, and so on in reactors and other irradiation research.

### III. Open Up the Depth and Breadth of Comprehensive Utilization of Reactors

Research and experimental reactors in China and foreign countries have done a great deal of work in the areas of reactor applied research and service in recent years and achieved rather good social benefits and definite economic benefits. On the basis of previous development, we should continue to exploit potential in the HFETR. While attempting to reduce operating costs, we should fully utilize the characteristics and advantages of the HFETR, meaning that we should complete and place into operation the 5MW low-power reactor as a supplement for rational utilization. Reinforce surveys of market conditions and user needs, information feedback, analysis, and policymaking, orient toward society and the national economy, and use the reactor as a basis and isotope products as a tap to open up and develop the depth and breadth of comprehensive utilization and form an integrated scientific research, production, and management body. Select projects correctly, establish an integrated system for materials, irradiation, processing,

and product production, achieve scale administration, and create more economic benefits and better social benefits.

#### A. Radioactive isotope development, production, and application services

As the number of heats and time of reactor operation increase at the HFETR, there can be substantial increases in isotope output and specific activity. Radioactive isotopes and their associated instruments are seeing ever-wider use in medicine, scientific research, and many industrial departments. High activity medical diagnosis isotopes produced by the HFETR like  $^{60}Co$  highly-radioactive medical treatment source,  $^{60}Co$ ,  $^{192}Ir$ , and other post-installation cavity medical treatment sources, and Mo-Tc and Sn-In isotope generators can satisfy national demand and we can carry out development and applied research on  $^{192}Ir$  wire-shaped insertable treatment sources,  $^{153}Gd$  bone density measurement sources,  $^{125}I$  X-ray machine sources,  $^{32}P$ ,  $^{35}S$ ,  $^{90}Sr$ - $^{90}Y$  isotope generators, and other pure B radioactive drugs,  $^{125}I$  and various radioactive immunization boxes,  $^{131}I$  labeled monoclonal antibody boxes,  $^{115}Cd$ - $^{115m}In$ ,  $^{191}Os$ - $^{191m}Ir$ ,  $^{109}Cd$ - $^{109m}Ag$ , and other medical isotope generators.

$^{60}Co$ ,  $^{170}Tm$ ,  $^{192}Ir$ , and other industrial  $\gamma$  flaw detection sources and matching flaw detectors are simple and convenient tools for use in non-destructive testing of pressure vessels and pipelines of all thicknesses used in the petrochemical, metallurgical, machinery, and other industries. There are also broad application and development prospects for various types of liquid position and materials position sources (counters) used in industry, isotope thickness meters and density meters, fire alarm sources,  $^{55}Fe$ ,  $^{109}Cd$ , and other fluorescent analysis sources,  $^{14}C$  and its labeled compounds, tracer isotopes used in petroleum well logging, water conservancy projects, and so on. The HFETR has obvious advantages and large batch supply capabilities in these isotope and irradiation production areas. We also should try to focus on source machine matching and applications service work, continually improve performance, and achieve automation and microcomputerization. We should establish an isotope and nuclear technology applied research center.

Moreover, using high-flux reactors for irradiation and production of transplutonium elements is an important project developed in foreign countries. The transplutonium elements  $^{238}Pu$ ,  $^{241}Am$ ,  $^{242}Cm$ ,  $^{242}Cm$ ... $^{251}Cf$ , and so on have important uses in nuclear medicine, the military, and high scientific and technical realms (such as heart pacemakers, space energy sources, and seabottom cable amplifiers).

#### 2. Irradiation processing research and applications

The HFETR and its 5MW low-power reactor have various types of neutron irradiation spaces and the largest irradiation processing capacity in China. The two reactors can irradiate 20 to 30 tons of monocrystalline

silicon annually. As China's electronics industry develops, demand for neutron transmutation doped monocrystalline silicon will gradually increase. While stabilizing and improving the quality of irradiation, we should develop irradiation research on large-diameter silicon, vertically-pulled silicon, semiconductor component performance control, and so on and actively seek foreign users and enter international markets. There are excellent development prospects for gem coloring, nuclear pore filter membranes, and so on.

Success has already been achieved in using the  $\gamma$  irradiation field of fuel elements removed from the HFETR and in the production of industrial cobalt sources in the area of radiation cross linking for heat shrinking to make polyethylene products, and irradiation processing will develop from plants that produce raw materials to producing products.  $\gamma$  irradiation modifies polymer materials and has a broad range of uses in the plastics and rubber industries and in the chemical, textile, precision petroleum refining, and other industries, and  $\gamma$  irradiation can be used for sterilization of medical machinery, drugs, cosmetics, etc., and for food preservation, breeding improved varieties, and so on. We should strengthen research, development, and cooperation, actively strive for and create the proper conditions, and establish a large irradiation station and associated plants at Chengdu with a design capacity of 1 million curies to make the Southwest China Irradiation Processing Applied Research Center and strive for even greater economic benefits and better social benefits.

#### **IV. Reinforce Domestic and International Exchanges and Cooperation**

The state spent an enormous amount of money to build the HFETR. To fully utilize it and make the appropriate contributions to the development of China's nuclear industry and S&T, we must make major efforts to develop domestic and international exchanges and cooperative applications.

The neutrons and  $\gamma$  field of the HFETR can provide research services for the development of the materials and nuclear fuels sciences, solid physics, neutron physics, radiation chemistry and irradiation chemistry, isotopes and their applications, and other areas. The relevant experts can come to the HFETR on fixed or non-fixed schedules for cooperative research as well as bring their own project topics. It can be used to train personnel for nuclear power plants.

Research organs, universities, and experts from Japan, the United States, Brazil, Chile, and the International Atomic Energy Agency have expressed interest in using the HFETR for research on materials irradiation, plate

fuel element inspection, nuclear measurements, low concentration of fuels used in research reactors, and other areas. We should try to create the conditions to make the HFETR China's window to the outside world, undertake wide-ranging substantive international cooperation and exchange, improve academic and technical levels in China, and promote the development of the nuclear sciences in China.

#### **V. Perfect the Facility, Make It a National Laboratory**

The HFETR is a large comprehensive experimental, engineering applications, and research facility and has also become known as a "tool reactor". It was not constructed mainly for its own unit or to serve the nuclear industry system, but instead should be an important link in the state's overall scientific development plans. Most research and experimental reactors of this type in foreign countries are national laboratories. Undertaking comprehensive utilization of the research reactor for China and foreign countries can provide definite economic benefits, compensate for part of the cost of its operation, and reduce the state's financial outlays. If we depend mainly on the reactor itself to continue operation, we will inevitably create many artificial obstacles that will greatly restrict utilization of the HFETR, which will lose the goals and importance of reactor construction to a substantial degree. This would have extremely negative long-term consequences for the nuclear industry and state S&T development.

To truly achieve opening up of the HFETR to the outside world and utilization, we must gradually perfect and improve the HFETR and its experimental facilities. Examples include updating of reactor equipment and instruments, perfection of safety facilities and processing of the three wastes (waste water, waste gas, and industrial residues), construction of irradiation loops, improvement of irradiation devices and technology, perfection of post-irradiation inspection and testing measures, and so on.

For this reason, the HFETR should become a national laboratory and receive key state support to confirm the status and role it should have. Make it one of the world's most advanced high-flux engineering test reactors, fully foster its advantages and functions for irradiation inspection of nuclear fuel and materials, promote a shift to domestic production in China's nuclear power industry and the development of power reactors and new types of energy source reactors, promote domestic and international cooperation and exchange and personnel training, promote wide-ranging applications of nuclear power and nuclear technology in all realms of China's national economy, accelerate improvements in the levels of nuclear S&T in China, and contribute to a takeoff in the cause of science during the 21st Century.

### New Fuel Cell Technology

916B0052C Beijing ZHONGGUO KEXUE BAO  
[CHINESE SCIENCE NEWS] in Chinese 25 Jan 91 p 1

[Article by reporter Yang Hong [2799 5725]: "Photoelectric Conversion Efficiency of Small-Area Non-Crystalline Silicon Solar Cells at World Vanguard Levels"]

[Text] After 5 years of hard work on a state task to attack key S&T problems that was undertaken by the Chinese Academy of Sciences [CAS] Semiconductor Institute during the Seventh 5-Year Plan, research on small-area high efficiency non-crystalline silicon solar cells, the job has been completed and recently passed examination and acceptance.

After the scientific research personnel in this topical group took responsibility for the task, they first cooperated with the CAS Shenyang Scientific Instruments Plant in making an independent decision to design and manufacture China's first three chamber ultra-high vacuum plasma reinforced chemical steam phase precipitation

experiment equipment and filled in a blank spot in China. On this foundation, they also explored and perfected a unique technique for subchamber transfer precipitation of non-crystalline silicon solar cells and then developed unijunction non-crystalline silicon solar cells with a maximum conversion efficiency of 11.19 percent ( $1 \text{ cm}^2$ ). This achievement was only preceded by the United States and Japan.

The relevant experts feel that this achievement has its own research characteristics, that its testing data are reliable, and that it fully satisfies the state task to attack S&T problems during the Seventh 5-Year Plan. Information announced by SERI at the 5th Photovoltaic Conference in 1990 indicates that this achievement has attained advanced international levels at the present time.

Also passing examination and acceptance was research on photo CVD technology cells. The examination and acceptance committee felt that this achievement also completed the indices and tasks stipulated for the attack on key S&T problems during the Seventh 5-Year Plan.



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